

SALMON BYCATCH IN THE BERING SEA TRAWL FISHERIES AND ALTERNATIVES FOR HOT-SPOT CLOSURE

A Discussion Paper
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INTRODUCTION

This discussion paper contains an analysis of alternatives for salmon bycatch management through hot-spot authority. The alternatives for chinook salmon bycatch management have previously been reported in Amendment 21b. An update of chinook salmon bycatch as presented in Amendment 21b is provided in this document. Alternatives for chum salmon bycatch management are provided in this document as well. The alternatives define areas for closure based upon existing management areas coincidental with high chum salmon bycatch, as well as discrete areas within larger management areas. Predefinition of areas for implementation of hot-spot authority allows non-discretionary closure ability by the Regional Director of the National Marine Fisheries Service (NMFS). Hot-spot authority without predefined areas for closure severely impacts the ability of NMFS to implement closures in a manner timely enough to be effective in bycatch management.

CHUM SALMON BYCATCH MANAGEMENT

Purpose of and need for proposed action

The request for an analysis of hot-spot authority grew out of the perception that bycatch actually occurs in small, discrete areas, and that the areas could be identified and closed quickly at a high savings in bycatch species with minimal impacts to the groundfish fishery. Unfortunately, based on the analyses presented below, salmon bycatch does not occur in small discrete areas at specific times. Additionally, closure of an area which has not been predefined for potential closure requires that specific guidelines be followed, including a public notification period. The process of implementing such a closure takes such a significant amount of time that the effectiveness of the closure is severely limited. Therefore, this document identifies several alternative areas with high chum salmon bycatch to provide a framework for preselection of areas for potential closure.

In 1993, the chum salmon bycatch in the Bering Sea of approximately 245,000 salmon more than tripled the previous high bycatch level, and was six times the bycatch level seen in the previous two years. Concerns about chum salmon bycatch were exacerbated by the poor returns to Western Alaskan systems in the same year. Commercial, sport and subsistence fisheries were closed in several of the Western Alaskan districts in 1993 because of poor returns, and projections for 1994 are for below average returns in many districts as well. The intercepted chum salmon were primarily in the size range of 3 year-old fish which would be expected to mature in the following year. The chum salmon were also captured after most of the Western Alaskan chum salmon would have returned to their native systems. Little is known about the potential impacts bycatch may have had on the following year returns, especially since stock composition of the bycaught salmon is unknown.

The purpose of this analysis is to provide managers with information needed to take possible action to reduce chum salmon bycatch in 1994 and/or subsequent years. However, although providing much of the data necessary for an EA/RIR, this analysis does not include the complex economic analysis an EA/RIR might require. This analysis examines domestic fisheries in 1990 - 1993 for patterns in chum salmon bycatch, however only the fisheries conducted in 1993 were in spatial and temporal patterns similar to those anticipated in the future. Regulations specific to 1993 and the future mandate the timing of the pollock "B" season (open August 15 as of 1993) and the position of the catcher-vessel operational area (CVOA) (effective June 1, 1992). In this discussion paper, areas for potential closure were defined based on the patterns in other salmon bycatch, especially in 1993. It is possible that more refined or alternative areas may become apparent as additional information becomes available. The smallest unit examined for potential closure in this document was the $1/2^\circ$ latitude by 1° longitude block. The distribution of chum salmon noted in historical fisheries covers a fairly large area, and is not necessarily confined to discrete areas smaller than blocks. Given the annual and inter-annual spatial distribution of high bycatch observations, a trade-off between potential groundfish catch and potential salmon bycatch becomes apparent. Either larger areas must be chosen in order to maximize potential bycatch savings, or smaller areas must be chosen in order to minimize closure impacts on existing groundfish fisheries.

Alternatives considered

In order to be effective for management, hot-spot authority requires the establishment of predefined areas for non-discretionary closure. A suite of alternative areas has been examined in this document. The areas described below were based largely on existing management areas or on 30 mi by 30 mi ($1/2^\circ$ latitude by 1° longitude) blocks corresponding to high other salmon bycatch. With the exception of a 15 mile buffer extending to either side of the 200 m depth contour, square blocks or areas previously defined (such as NMFS management area 517) were chosen for ease of enforcement. In several alternative areas, blocks were selected which would maintain access to the lucrative "horseshoe" area which, although containing other salmon bycatch, did not account for inordinantly high other salmon bycatch. The seven alternative areas and two sub-alternatives examined in this report are as follows:

1) "Contour". A 15 mile buffer extending to either side of the 200 m depth contour which extends to the north and west from the "horseshoe" and Unimak Island (Figure 1). This contour buffer was found to correspond to high chinook salmon bycatch as presented in Amendment 21b to the Bering Sea Groundfish FMP.

1b) "Contour within CVOA". The portion of Alternative 1 falling within the CVOA as described in Alternative 3.

2) "Contour plus Unimak". The area defined under (1) above in addition to two blocks to the north of Unimak Island and the "horseshoe" (Figure 1). The combination of these blocks with the contour buffer accounted for a high percentage of chinook bycatch in Amendment 21b.

2b) "Contour within CVOA plus Unimak". The portion of Alternative 2 falling within the CVOA as described in Alternative 3.

3) "CVOA". The catcher-vessel operational area (CVOA) as currently described for management of nearshore and offshore fisheries during the pollock "B" season (Figure 2).

4) "Area 517". NMFS management area 517 (Figure 3).

5) "9 blocks". The nine blocks which form the top portion of the CVOA extending to the west from Unimak Island, and including a block above the northwest corner of the CVOA (Figure 4).

6) "5 blocks". The five blocks approximating the north-central portion of the CVOA (Figure 5).

7) "7 blocks". The seven blocks identical to those described in Alternative (5) with the two above Unimak Island removed (Figure 6).

Background

Data:

The data used in this document are observer data collected, compiled and provided by the NMFS observer program. The observer data is for individual hauls, and the bycatch numbers from each haul have been expanded as necessary from the sample to the whole haul if applicable. Bycatch species composition is determined for selected hauls during the year. The composition of hauls for which the species composition was not determined is estimated as described in Amendment 21b. Assignment of target species is also as in Amendment 21b. The current analysis includes only those vessels which were defined as pelagic trawl for pollock, bottom trawl for pollock and bottom trawl for Pacific cod since these fisheries have been previously identified as having high salmon bycatch. Except as noted, only the data from observed hauls were analyzed in this document. The data has not been expanded to include unobserved hauls for the entire fleet. Data from 1993 are estimated to contain 90% of observer data as available at the time.

The primary data used in determining areas of high chum bycatch are from the 1990 - 1993 domestic fisheries. Since 1993 is the only year representing the current management regime, bycatch from 1993 was the primary source for spatial and temporal analysis.

Species composition of bycaught salmon:

Although the term "other" salmon is used consistently throughout this report for non-chinook bycaught salmon, the majority of the other salmon are likely to be chum salmon. Annual NMFS observer reports of the foreign and Joint Venture (JV) fisheries estimated the number of each

species of salmon bycaught in the historic trawl fisheries (1980-1989, as in Berger et al. 1984 and Guttormsen et al. 1990). Domestic reporting (since roughly 1989) available on the NMFS Bulletin Board has been generally divided into two categories: chinook salmon and "other" salmon. Examining the foreign and JV trawl fisheries for which species composition had been reported, an annual average of approximately 95% of the "other" (non-chinook) species bycaught in the Bering Sea were chum salmon. This average is actually conservatively low because the two lowest values in computing the average (71% and 84%) were taken from early JV fisheries which captured less than 2,500 salmon in total.

Figure 7 shows the historic percentages of "other" salmon which were chum salmon in the Bering Sea foreign and JV fisheries as reported by the NMFS observer program (as in Berger et al. 1984 and Guttormsen et al. 1990). These percentages are also plotted against the percentage of all salmon which were chinook in any given year. The plots indicate that in the Bering Sea, the percentage of "other" salmon which were chum salmon was fairly consistent regardless of the ratio of chinook salmon to all other species. In this report, "other" salmon refers to all non-chinook salmon, and consists almost entirely of chum salmon.

History:

Directed catch

The directed commercial catch of chum salmon for the entire state of Alaska has varied between 8 and 15 million fish since 1980 (Figure 8). The commercial catch of chum salmon in the AYK Region (Norton Sound, Kotzebue, Yukon and Kuskokwim fisheries) has varied between 1.2 and 2.8 million fish between 1980 and 1992. However, as reported to the NPFMC in January 1994 (Agenda D-2(a)(3)), only approximately 360,000 chum salmon were taken in the 1993 commercial fisheries (RAVEN Commission Report, ADF&G, 1994). In spite of commercial, recreational and subsistence fishery closures, many systems did not meet minimum escapement goals. As indicated in the RAVEN report, chum salmon catches in the Westward (Chignik, Kodiak, and Aleutian Island/Alaska Peninsula fisheries) and Central (Prince William Sound, Cook Inlet, and Bristol Bay fisheries) districts were below average in 1993 as well.

Bycatch

The other salmon bycatch in the Bering Sea was approximately 245,000 fish in 1993. This level of bycatch exceeded the previous year's bycatch of approximately 39,000 other salmon by six times, and was triple the previous highest bycatch amount of approximately 72,000 other salmon estimated in the 1984 foreign trawl fishery (Figure 9). Other salmon bycatch was below 10,000 fish both prior to 1983, and between 1987 and 1989.

Other salmon bycatch is generally reduced during the winter months when, conversely, chinook salmon bycatch is high. Although few other salmon are normally encountered during the winter months, there are years when fairly significant numbers can be taken. For instance, roughly 8% (based on composition of observed hauls) of the other salmon bycatch was taken during the first

two months of 1992 (Figure 10, top) when approximately 39,000 other salmon were bycaught in total. Approximately 4,300 other salmon have been taken during the pollock "A" season of 1994 (NMFS Bulletin Board report dated 3/25/94), and it remains to be seen whether this amount will be anomalously high or a small proportion of the total bycatch as in many of the previous years. The bycatch of other salmon in 1993 was very small in all months prior to July and August of the year.

Historically, other salmon bycatch has been elevated during the months of July through October (Figure 10, top). Approximately 67% of all other salmon in observed hauls were bycaught during August of 1991, and approximately 62% of all other salmon were taken during the month of September in 1993. In spite of the June opening of the pollock "B" season in 1991 and 1992 (evident in Figure 11), few chum salmon were bycaught until July, August and September during those years. The delay of the "B" season opening until August 15 in 1993 corresponded to high chum salmon bycatch in August and September of that year.

During the last four years (1990-1993), groundfish catch has been highest during the months of January - March and June - September, with the exception of the 1993 implementation of the pollock "B" season delay which postponed fishing from June until mid-August (Figure 11, bottom). The mean chinook salmon bycatch rate (expressed as the mean per-vessel rate in number of salmon per metric ton of catch) is highest during the periods January - April and October - December (Figure 12, bottom). The highest proportion of chinook salmon were bycaught during the first four months of any of these four years (Figure 12, top). The mean bycatch rate for other salmon is highest between July and October which corresponds to the period of highest percentages of annual bycatch (Figure 10).

Spatially, other salmon bycatch tends to be highest south of 57° N latitude and east of 168° W longitude, whereas chinook salmon bycatch tends to be more widely distributed to include the area along the 200 m depth contour which extends to the north and west. The spatial distribution of salmon bycatch from observed hauls over the period 1990 - 1993 is presented graphically in Figures 13 - 20 for both other and chinook salmon. Other salmon bycatch tends to be highest in the portion of the Bering Sea near Unimak Island and the "horseshoe", and extending along the Bering Sea shelf to the north and east of the 200 m contour (roughly in the vicinity of the CVOA and NMFS management area 517). The general location of fishing effort during the period 1990 - 1993, and the locations of hauls with high bycatch of other salmon (e.g. > 50 other salmon in a haul) are presented in Figures 21 - 28. The hauls containing 50 or more other salmon represented 43%, 54%, 63% and 82% of the total other salmon observed in 1990, 1991, 1992 and 1993, respectively.

Spatial analysis of the other salmon bycatch data does not appear to indicate precisely defined small-areas which could be closed under a hot-spot authority. As a general observation, bycatch of other salmon can apparently occur patchily along the 200 m contour, especially during the second half of the year, however, by far the majority of other salmon bycatch is concentrated in the area of the horseshoe and above Unimak Island on the shelf south of 57° N latitude and east of 168° W longitude.

Analysis of the alternatives

The following analysis presents the proportion of catch and bycatch taken from each of the seven alternative areas during 1990 - 1993. Although statistics from 1990-1992 are important in indicating trends in other salmon bycatch and potential impacts to fishing fleets, 1993 is the only year in which fisheries management options and the distribution of fishing effort are likely to be similar to the 1994 and future fisheries. It should be noted that it is primarily the observations from a single year (1993) which have been used to select relevant areas for hot-spot closure authority.

Catch and bycatch numbers were expressed as proportions of annual totals in order to provide year-to-year comparison. It should be noted that several of the defined areas overlap and contain portions of the areas in other alternatives. As Figure 29 (top) indicates, the highest percentage of the total annual weight of observed groundfish catch (35% - 55%) was taken within 15 miles of the 200 m contour and in the two blocks to the north of Unimak Island and the "horseshoe" (Alternative 2). Catch within the CVOA (Alternative 3) has increased annually to account for more than 50% of the total observed groundfish catch in 1993, and catch in Area 517 (Alternative 4) approximately doubled from previous levels to account for roughly 50% of the total annual groundfish catch from the Bering Sea in 1993. Of the alternatives comprised of selected blocks with high other salmon bycatch, annual groundfish catch within these areas in 1993 approximately doubled from previously observed percentages to account for roughly 27%, 23% and 16% of the total annual groundfish catch from the 9 blocks, 5 blocks and 7 blocks (Alternatives 5 - 7), respectively. Graphs of the number of hauls by area were nearly identical to the patterns indicated for groundfish catch.

Other salmon bycatch is significant between the months of July - October, and closures of identified areas would only be made during this period. Therefore, the effort and catch from within this period was compared with the effort and catch from the entire year. The contour and Unimak Island blocks (Alternative 2) during this period accounted for nearly 30% of the annual groundfish catch in 1993, up more than 10% from previous levels during 1990 - 1992 (Figure 29, bottom). The percentage of CVOA (Alternative 3) catch during this period jumped from approximately 10% of the annual total groundfish catch to more than 25% of the catch, and the catch in Area 517 (Alternative 4) approximately tripled during this period in 1993 to account for nearly 30% of the total annual catch. The individual blocks selected for closure under Alternatives 5, 6 and 7, represented an insignificant percentage of the total annual groundfish catch during this period until 1993 when they accounted for between 7% and 10% of the total annual catch.

The area which most consistently accounted for other salmon bycatch from year to year was the CVOA (Alternative 3) which represented between 78% and 82% of the total annual other salmon intercepted in the Bering Sea since 1990 (Figure 30, top). The contour buffer and two Unimak Island blocks (Alternative 2), much of which lies within the CVOA, accounted for 82% and 86% of the total annual other salmon catch in 1991 and 1992, respectively, however in 1993 only 55%

of the total annual other salmon bycatch came from this area. Other chum salmon bycatch in Area 517 (Alternative 4) has ranged between 27% and 88% of the annual total. Of the three selected block configurations, the 9 blocks (Alternative 5) accounted for between 39% and 50% of the total annual other salmon bycatch prior to 1993 (in spite of small catch from these blocks), and 68% of the total annual other salmon bycatch came from this alternative in 1993. Because almost all of the other salmon bycatch occurs between the months of July and October, the figure comparing the bycatch during this period (Figure 30, bottom) to the entire year is nearly identical to the figure above for the annual catch within areas.

The bycatch of other salmon is a function of both the availability of other salmon as well as intensity of effort in the areas within which other salmon appear. The high bycatch of other salmon in 1993 was primarily due either to an increased number of other salmon available, or an increased effort at the time and areas in which other salmon occur. In 1990, effort was fairly constant throughout the year, and chum salmon bycatch was low. It is possible that the number of other salmon available in the Bering Sea was much lower than that available in 1993. However, fishing effort in 1990 was largely to the north (e.g. 25% of the groundfish catch came from the CVOA and 17% from Area 517, Figure 29, top) and almost no catch was taken from the 5 blocks, 7 blocks or 9 blocks (Alternatives 7, 6 and 5). Yet in spite of the very low catch from these block alternatives, 34%, 39%, and 14% of the other salmon bycatch came from the 5 blocks, 9 blocks, and 7 blocks in 1990, respectively (Figure 30). A similar pattern was observed in the 1991 and 1992 fisheries.

As discussed above, in 1993 there was a shift of effort to the south in the region of the CVOA and Area 517 (Figure 27). Of the alternatives considered, the contour buffer accounted for the smallest number and percentage of other salmon encountered in 1993 (roughly 30% of the other salmon bycaught between July and October). Only roughly 24% of the other salmon bycaught within the contour buffer (or roughly 9% of the other salmon bycaught in the Bering Sea between July and October) were in the portion of the contour outside of the CVOA. The majority of other salmon caught within the vicinity of the 200 m contour are taken south of 56° N latitude and east of 168° W longitude. Because the majority of other salmon are taken within the CVOA, the north-west extent of the CVOA was chosen as the north-west boundary of the contour buffer under Sub-alternatives 1b and 2b.

In order to more closely examine the portion of the contour buffer which lies within the CVOA, the catch, number of hauls, and bycatch of chinook and other salmon were summed separately for the following exclusive areas: 1) the portion of the contour buffer which lies within the CVOA; 2) the two Unimak Island blocks; 3) the remainder of the CVOA; 4) the contour buffer which lies outside of the CVOA; and 5) the remainder of the Bering Sea. Figures 31 - 33 provide the percentage catch or bycatch which occurred within each of the above areas during the years 1990 - 1993.

The increase in the percentage of hauls and groundfish catch in the Unimak Island blocks and the CVOA as a whole (e.g. the sum of the contour, the Unimak blocks and the remainder of the CVOA, but excluding the portion of the contour outside the CVOA and excluding the rest of the

Bering Sea) are apparent in Figure 31. During the months of July through October in 1990 - 1992, groundfish effort and catch had been concentrated within the remainder of the Bering Sea, and the portion of the contour buffer which lies outside of the CVOA (Figure 32). The shift of effort and increased catch in all portions of the CVOA was apparent in the 1993 groundfish fisheries.

As can be seen in Figure 33 (top), the area within the CVOA has consistently accounted for approximately 80% of the total other salmon bycatch. In 1993, other salmon bycatch was approximately six times that encountered in 1991 or 1992. However, the percentage of other salmon bycatch inside and outside the CVOA remained constant in spite of the increase in catch and effort inside the CVOA. This could either indicate an overall increase in the availability of other salmon, or an increased availability with the time of year, since the proportion of other salmon encountered in September was much higher than in previous years.

The increase in effort in the portion of the CVOA outside of the contour buffer or the Unimak blocks lead to a disproportionate increase in the percentage of other salmon bycaught in that area when compared to the percentage of groundfish catch the area represented.

Oceanography

As can be seen in Figure 28 which shows the location of all hauls containing 50 or more other salmon in 1993, the distribution of other salmon appears to approximate a circle or oval which extends from Unimak Island northwest to the Pribilof Islands and remains on the shelf side of the 200 m contour. Although requiring further exploration, there is a possible physical explanation for this pattern in the distribution other salmon. Ocean currents entering the Bering Sea through Unimak pass tends to flow north both along the 200 m isobath (outer front) and the 100 m isobath (middle front) as discrete fronts first described by Coachman et al. 1980 and reproduced in McRoy et al. 1985 (Figure 34). The pattern of other salmon distribution roughly corresponds to the outer domain, or the area between the middle front and the outer front. The formation of the middle and outer fronts provides for an area of lateral mixing of Bering Sea basin water with shelf water in the outer domain (McRoy et al. 1985). As described in McRoy et al. 1985 (Figure 35), the outer domain is an area of primary production for the pelagic community which includes pollock. It appears that between July and October, the outer domain is also important to other salmon. A possible alternative area of protection for other salmon might be the area of the outer domain bounded to the south and west by the 200 m contour and to the north and east by the 100 m contour.

Summary of alternatives

In summary, seven alternative areas and two sub-alternatives were examined for potential closure due to other salmon bycatch. As discussed below, the economic and social impacts of such closures have not been determined because of the complexity of factors involved. The relative impacts on groundfish catch and other salmon bycatch due to such closures have been examined

by comparing the historic percentage of catch and bycatch from each of the areas.

Alternative 1:

The first alternative, closure of a 15 mi buffer on either side of the 200 m contour was suggested in Amendment 21b as a means of controlling chinook salmon bycatch. Such a closure does not appear to be an efficient means of controlling other salmon bycatch. Only a small proportion of the other salmon bycaught within the contour were captured north of 56° N latitude or west of 168° W longitude. Thus a closure of the northern portion of the contour buffer would come at a high cost to industry with minimal savings in other salmon. For example in the period of July - October, approximately 25% of the total 1993 groundfish catch came from the contour buffer, and roughly 33% of the total 1993 other salmon came from the contour buffer during this period - almost all from the southern portion of the contour. A preferred Alternative would be the sub-alternative below.

Sub-alternative 1b:

Closure of a 15 mi buffer on either side of the 200 m contour within the CVOA. The portion of the contour buffer which lies outside the CVOA has only accounted for between 3% and 13% of the total bycatch of other salmon during the months of July - October. The portion which lies within the CVOA, on the other hand, has consistently accounted for between 25% and 42% of the total other salmon bycatch during this period. However, the percentage of the groundfish catch in this area during July - October is similarly between 17% and 36% since this is an area of high fishing activity.

Alternative 2:

Inclusion of the two blocks north of Unimak Island with the contour buffer as in Alternative 1. This alternative increases the percentage of other salmon bycatch over Alternative 1. However, as with Alternative 1, the northern portion of the contour buffer, while providing savings for chinook salmon during winter months, does not appear to be an important area for other salmon during the summer/fall months. A preferred Alternative would be the sub-alternative below.

Sub-alternative 2b:

Inclusion of the two blocks north of Unimak Island with the contour buffer within the CVOA as in Sub-alternative 1b dramatically increases the number of other salmon bycaught within the area. Individually, the two Unimak blocks accounted for between 23% and 37% of the other salmon bycatch during July - October and only 1% - 7% of the total groundfish catch during the same period. The combined area of the contour buffer within the CVOA and the Unimak Island blocks accounted for between 47% and 77% of the other salmon bycaught between July and October, and between 18% and 43% of the total groundfish catch during the same period.

Alternative 3:

Closure of the CVOA. Although this area has consistently accounted for approximately 80% of the other salmon bycatch during the last four years, the CVOA has also become increasingly important to groundfish fishermen. The CVOA accounted for between 19% and 33% of the total groundfish catch for the Bering Sea during the months of July - October in 1990 - 1992, and

accounted for 53% of the groundfish catch in 1993. It is possible this increased effort in the CVOA has helped increase other salmon bycatch levels. It is noteworthy that the other salmon bycatch in the portion of the CVOA in 1993 which was not in the Unimak Island blocks or the contour buffer accounted for an unexpectedly high portion of the other salmon bycatch (33%), for an increase in groundfish catch of a disproportionately small amount (9%) (see Figures 32 and 33). With the regulations restricting access by processor type and designation, the CVOA has become more important to the near-shore fishermen. Closure of the entire area to reduce other salmon bycatch would, as current regulations stand, place a greater burden on near-shore fishermen.

Alternative 4:

Closure of Area 517. Area 517 comprises the northwest portion of the CVOA and extends to the north and west to near the Pribilof Islands. This area has accounted for between roughly 27% and 87% of the total annual other salmon bycatch taken during the months of July - October. Due to the high degree of overlap between Area 517 and the CVOA, the percentage of groundfish catch and other salmon bycatch which were taken from Area 517 within the CVOA was estimated. Examining the groundfish catch taken during the months of July - October, 98%, 83%, 96%, and 78% of the catch was taken within the CVOA in 1990 - 1993, respectively. Similarly 100%, 97%, 99%, and 81% of the other salmon bycatch from Area 517 was taken within the CVOA in 1990, 1991, 1992, and 1993, respectively. Thus the portion of Area 517 which lies outside of the CVOA is marginally important for groundfish catch, and, with the exception of 1993, insignificant for other salmon bycatch.

Alternative 5:

Closure of 9 blocks, eight making up the northern portion of the CVOA and one outside at the northwest end. These blocks do not include the horseshoe area which is important to groundfish as well as salmon. As discussed above, the increase in effort in the portion of the CVOA outside of the contour buffer or the Unimak blocks (9% of groundfish catch) lead to a disproportionate increase in the percentage of other salmon bycaught in that area (33%). Groundfish catch during July - October within the nine blocks accounted for between 1% and 2% of the total annual groundfish catch between 1990 and 1992 and accounted for 10% of the total annual groundfish catch in 1993. Of the groundfish catch taken only during July - October, the nine blocks comprised between 1 and 5% of the total groundfish catch between 1990 and 1992 and 21% of the total groundfish catch during that period in 1993. Between 39% and 44% of the total annual other salmon bycatch was taken from these nine blocks between July and October of 1990 - 1992, and 67% of the total annual other salmon bycatch was taken from these blocks in 1993. It should be noted that some of the nine blocks, particularly to the north and west have historically had very little effort. Because these blocks abutted squares with high salmon bycatch, they were included in the nine blocks under the assumption that given increased effort, these blocks would also have high bycatch.

Alternative 6:

Closure of 5 blocks approximating the northern center of the CVOA which includes the two Unimak Island blocks. These blocks were chosen as a minimum closure area which would still

allow access to the lucrative horseshoe area. Although reduced in area from Alternative 5, this alternative accounted for between 1/3 and 1/2 of annual other salmon bycatch. During the period of July - October, this alternative accounted for .4% 1% .8% and 7% of the total annual groundfish catch in 1990, 1991, 1992 and 1993, respectively. During the same period the alternative also accounted for 33%, 38%, 40%, and 54% of the total annual other salmon bycatch for the years 1990 - 1993, respectively.

Alternative 7:

Closure of 7 blocks contained under Alternative 5, but allowing access to the two eastern-most blocks. This alternative accounted for similar groundfish catch levels as reported under Alternatives 6 and 7 above. Bycatch levels were also similar to the two alternatives above during 1993 (59% of total annual other salmon bycatch taken between July and October). However, other salmon bycatch occurred more in the eastern portion of the CVOA in 1990 - 1992, and blocks under this alternative only accounted for 14%, 16% and 24% of the total annual other salmon bycatch during this period in 1990, 1991 and 1992, respectively. It appears that the eastern block of the Unimak blocks, and the block above it more consistently account for other salmon bycatch than do the blocks more to the west included under Alternative 7 and an area of high salmon bycatch in 1993.

Of the seven alternatives and two sub-alternatives, Alternative 5 which covers a broad area but has not been heavily fished until 1993 would provide the most consistent protection to other salmon during the months of July - October while allowing access to the area of the horseshoe. Alternative 6 would provide reduced protection given the inter-annual variability in the distribution of other salmon within the vicinity of the CVOA. In order to provide another means of assessing the alternatives, the number of other salmon encountered for each metric ton of groundfish catch is provided in Figure 36. Bycatch per metric ton of groundfish was higher in 1993 than in previous years under all alternatives, but has been higher in all years under Alternatives 5 (9 blocks) and 6 (5 blocks). The alternative with the highest bycatch of other salmon for each metric ton of groundfish catch was Alternative 6.

Trigger for closure of selected alternative

If one of the above alternatives is chosen as a means of reducing the bycatch of other salmon in the Bering Sea, it is probable that a bycatch level or cap would need to be identified to trigger the closure. As indicated in Figure 9, other salmon bycatch in the domestic fisheries prior to 1993 was approximately 16,000, 36,000, and 39,000 fish in 1990, 1991 and 1992, respectively. The average of these three years is 30,300 fish, which might be considered as a cap level. The average of the 1991 and 1992 other salmon bycatch levels is 37,500 fish, which also might be considered. The highest level in the domestic fishery was the 1992 level of 39,000 fish, another possible cap.

Because the 1993 bycatch levels were so much higher than anything seen previously, it is difficult to determine what the effects of various cap levels might be. Any of the cap levels

mentioned above would have had negligible effects on the groundfish fisheries as they occurred in 1990 - 1992, and there would have been little impact on chum salmon bycatch because bycatch at the end of the season was similar to the cap. Given any of the above mentioned caps during the 1993 fishery, however, the fisheries would have been closed out of the selected area after the first or second weeks of fishing (Figure 37). The approximate bycatch by week in 1993 was as follows:

<u>Week Ending</u>	<u>Other salmon bycatch</u>
8/21	37,000
8/28	26,000
9/04	46,000
9/11	35,000
9/18	23,000
9/25	42,000

Economic Analysis

As described above, the area of high chum salmon bycatch is generally in the catcher-vessel operational area (CVOA) and NMFS management area 517 (the two areas overlap). Chum salmon bycatch also tends to be highest in the months of July through October, in the middle of which the pollock "B" season opening on August 15 occurs. Because of the time and area related management measures currently in place, and because of the interactions of current fishery components, an economic analysis is confounded by several factors and is not simply a matter of assuming that foregone catch from one area would be displaced to another area. Any chum salmon bycatch management measures can be expected to disproportionately affect processors or near-shore fishermen who fish in the CVOA; changes in the opening of the "B" season can affect product quality; and given the inability of several Western Alaskan systems to meet escapement requirements, the valuation of the bycaught chum salmon is no longer simply a matter of assuming potential losses to commercial fishermen. The complexities of the issues preclude a detailed economic analysis in the present document.

CHINOOK SALMON BYCATCH MANAGEMENT - updated analysis for Amendment 21b

Background

Amendment 21b provided an analysis of chinook salmon bycatch by trawl vessels operating in the Bering Sea groundfish fisheries. The analysis was based upon haul by haul observer data from the foreign and JV fisheries 1980-1989 and for the domestic fisheries 1989-1991. This update includes observer information from 1992 and the majority of the observer information from 1993 (90%).

The 1992 bycatch of chinook salmon by domestic trawl fisheries of 37,372 fish was surpassed in 1993 with an estimated bycatch of 46,483 fish (Figure 38) as reported by the NMFS Bulletin Board. The preliminary 1994 chinook salmon bycatch is estimated to be 34,868 chinook salmon through the week ending 4/2/94. The bycatch of chinook salmon in 1994 had higher per week increases than in any of the previous four years (Figure 39). (Note in the figure that catch by week data for the end of 1993, an additional 5-6,000 chinook, was not available at the time this chart was prepared.) Since chinook salmon bycatch tends to increase in the months of September - December, the total for 1994 is likely to exceed that seen in 1993.

Among the geographic-based alternative areas for management of chinook salmon bycatch analyzed in Amendment 21b were the following: 1) a buffer strip extending for 15 miles on each side of the 200 m contour; 2) three blocks at the horseshoe; 3) a single block at the horseshoe; and 4) the two Unimak Island blocks. Locations of chinook salmon bycatch indicated that the 200 m contour and the Unimak Island blocks accounted for a large portion of chinook salmon bycatch. The Bering Sea Bycatch Model predicted that closure of only the blocks, for instance at the horseshoe, would still allow high bycatch to occur as effort moved to other areas of high salmon bycatch (e.g. along the contour). The contour and Unimak Island blocks are also of high importance to groundfish fishermen because they are apparently highly productive for pollock.

Additional alternatives

Hauls with a chinook salmon bycatch of more than twenty fish between 1990 and 1993 have been plotted in Figure 40. As was found in Amendment 21b, the primary location of chinook salmon bycatch lies within the contour buffer and in the vicinity of Unimak Island during most years. In 1992, increased chinook bycatch occurred in the vicinity of the Pribilof Islands outside of the contour buffer and in the block north of the western Unimak Island block. The CVOA has been outlined in Figure 40, and blocks which appear to have higher concentrations of chinook salmon appear with cross-hatching.

In order to update Amendment 21b and investigate potential areas for closure smaller than the entire contour, the groundfish catch and chinook salmon bycatch from the following four alternatives were examined: 1) a 15 mile buffer strip along the 200 m contour; 2) the contour

buffer and the two blocks above Unimak Island (Figure 1); 3) 8 blocks as indicated in Figure 41; and 4) 9 blocks as indicated in Figure 42.

Figures 43 - 46 provide the percentage of chinook salmon bycatch (the top of each graph) and total groundfish catch (bottom of each graph) by month for January - April and September - December in 1990 - 1993. The percentages are cumulative with the cumulative percentage of the entire Bering Sea catch or bycatch ending at 100% in December of each year.

In 1990 and 1991, more of the groundfish catch was taken in the contour alternative and the contour and Unimak blocks alternative than in the 8 block or 9 block alternatives. The combination of the Unimak blocks and the contour buffer accounted for the highest percentage of the total groundfish catch in all four years (38%, 60%, 39% and 53% in 1990, 1991, 1992 and 1993, respectively). The highest percentage of groundfish catch taken in the contour was in 1991 when 51% of the total groundfish catch for the months of January - April and September - December was taken. The Unimak blocks accounted for an additional 9% of the groundfish catch in 1991, and an additional 3% in 1990. In 1992, on the other hand, only 27% of the total groundfish catch was taken in the contour and an additional 11% (for a total of 39%) of the total groundfish catch was taken in the Unimak blocks. This was approximately the same percentage (39%) taken in both the 8 block and 9 block alternatives in 1992. In 1993 there was a smaller percentage of groundfish catch taken in the contour buffer (34%) than in the other alternatives as well. An additional 19% of the total groundfish catch was taken in the two Unimak blocks in 1993. The percentage of groundfish taken from the 9 blocks has increased each year from 1990 - 1993 (20%, 36%, 38%, and 49%, respectively).

The contour buffer and two Unimak Island blocks accounted for the highest percentage of chinook salmon in 1990 (80%), 1991 (83%) and 1993 (70%). In 1992, however, the contour buffer and Unimak blocks accounted for 54% of the total chinook bycatch which was less than that found in the 8 block (61%) or the 9 block (64%) alternatives. This reduction of bycatch in the contour buffer during 1992 is coincidental with the reduction of groundfish catch from the contour in 1992. As mentioned above, the Unimak blocks accounted for 11% of the groundfish catch in 1992 and this area accounted for 19% of the total chinook bycatch. The 9 block alternative accounted for 52%, 66%, 64% and 60% of the total chinook bycatch over the years 1990 - 1993, respectively, which does not necessarily mirror the increased amount of groundfish from that area in each year.

There is a high degree of overlap between several of the areas as outlined above. In order to examine the patterns in chinook salmon bycatch with regard to the selected areas, the catch and bycatch from non-overlapping segments were determined for the months of January through April and September through December. The following mutually exclusive areas were examined: 1) The portion of any of the 9 blocks which fell within the 15 mi contour buffer; 2) the remainder of the contour buffer which did not overlap any of the 9 blocks; 3) the two Unimak Island blocks; 4) the remainder of the 9 blocks which did not overlap the contour and were not either of the Unimak blocks; and 5) the remainder of the Bering Sea.

The highest proportion of total groundfish catch taken in these discrete areas was the remainder of the Bering Sea in 1990 (58%), 1992 (49%) and 1993 (40%), and in the section of the contour buffer which did not overlap the 9 blocks in 1991 (40%)(Figure 47). There was an increase in the percentage of catch taken from the portion of the 9 blocks which overlap the contour and from the Unimak blocks in 1993 (23% and 19%, respectively). Generally, as mentioned above, there has been an increase in the percentage of groundfish taken in the Unimak Island blocks and in the 9 blocks over time.

The area defined by the overlap of the contour buffer with the 9 blocks accounted for the highest percentage of chinook salmon bycatch in 1990 (42%), 1991 (52%), and 1993 (32%). In 1992 this area accounted for 24% of the chinook salmon bycatch and the remainder of the Bering Sea also accounted for 24% of the total chinook bycatch in 1992. In 1990, 1991, and 1993 the portion of the 9 blocks which does not overlap the 200 m contour buffer accounted for only a small percentage of the chinook bycatch. This portion of the 9 blocks outside of the contour accounted for a high percentage of chinook only in 1992 when the percentage of chinook encountered within the contour was reduced (although groundfish catch was fairly constant in this area). The section of the contour outside of the 9 blocks has accounted for the second largest percentage of chinook bycatch in all years except 1992.

Summary

In summary, the area defined by a 15 mi buffer on either side of the 200 m contour and the two Unimak Island blocks have consistently accounted for the highest percentage and numbers of chinook salmon bycaught in the Bering Sea. Bycatch can, however, also occur outside of this area as was the case in 1992. The contour buffer and Unimak blocks are also important to the fishing fleet, and closure of this area could lead to high costs to industry if groundfish were not as available outside the closed area. A smaller area closure such as the alternative with 9 blocks could potentially reduce chinook salmon bycatch while allowing groundfish catch along large portions of the contour. However, chinook salmon bycatch occurs all along the contour and increased effort in any portion of the contour would be expected to be accompanied by chinook salmon bycatch. Although representing key areas of high salmon bycatch, it is difficult to estimate the bycatch levels which would occur if these blocks were closed and fishing continued along the 200 m contour.

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Figure 1. Bering Sea with 200 m depth contour portrayed as a dashed line. A buffer extends 15 mi on each side of the contour. The two $1/2^\circ$ latitude by 1° longitude "Unimak blocks" are blackened.

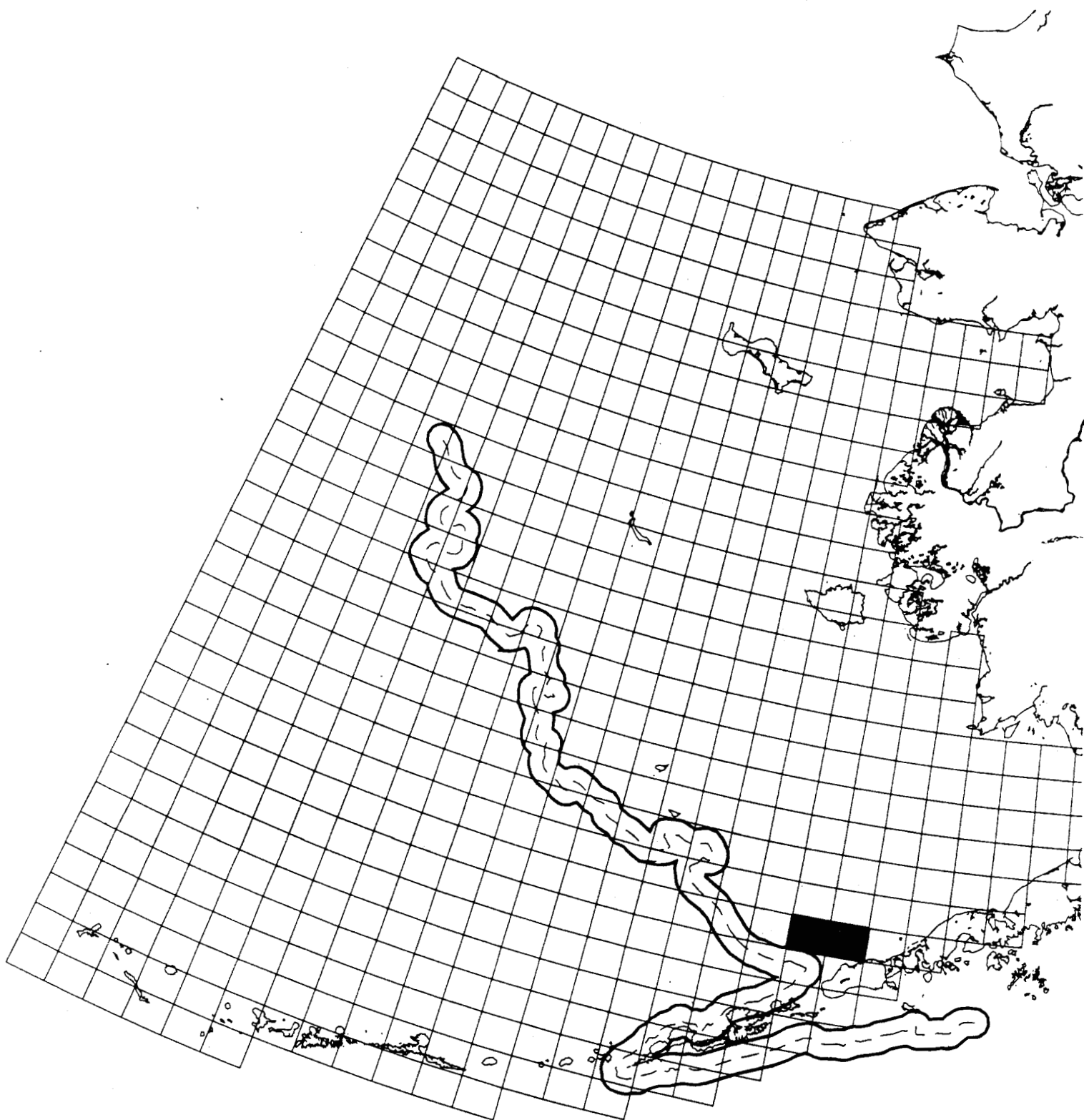


Figure 2.

The location of the catcher-boat operational area (CVOA) in the Bering Sea. Northern boundary is 56° N latitude, western boundary is 168° W longitude, and eastern boundary is 163° W longitude.

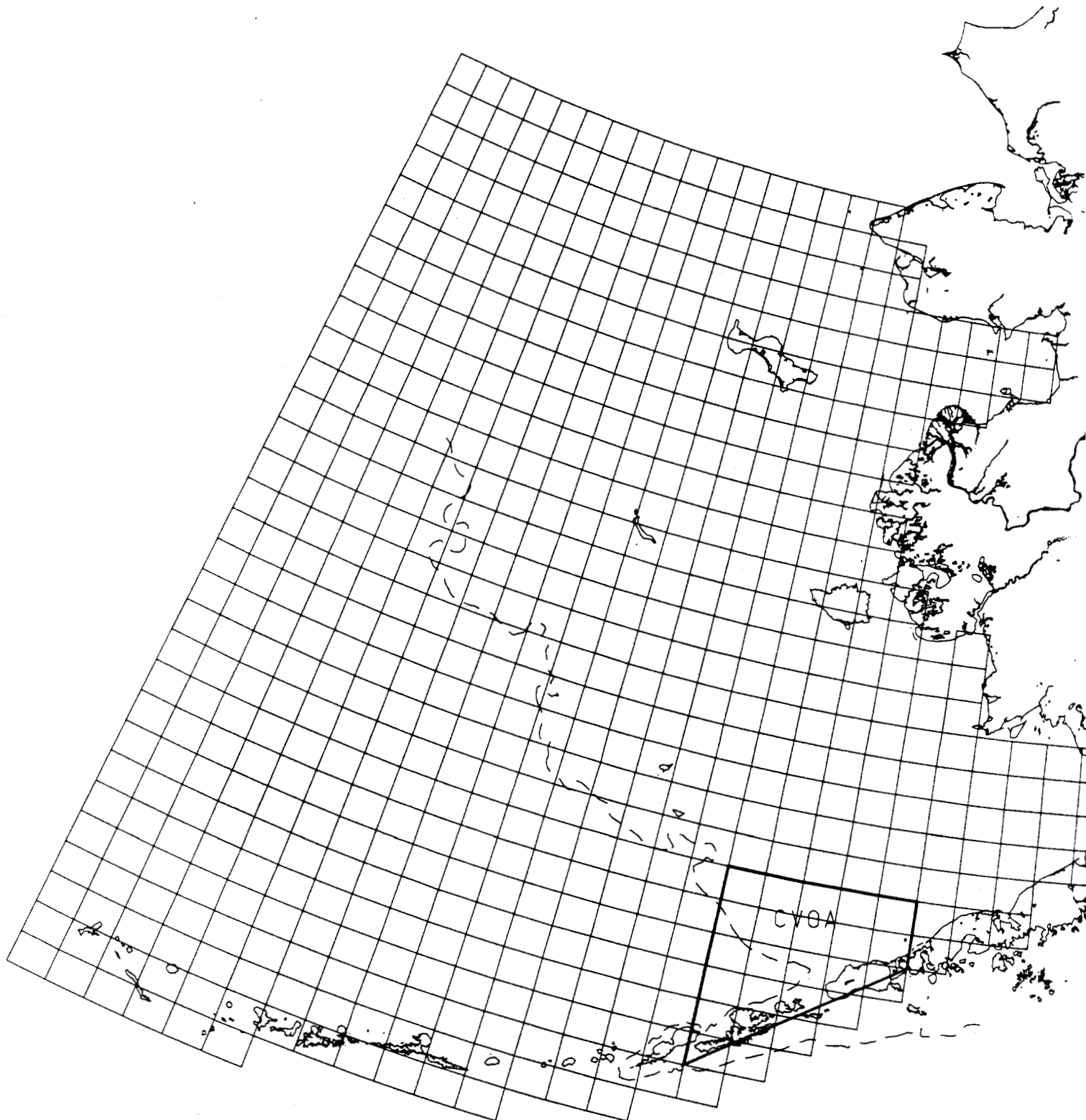


Figure 3. NMFS management areas with Area 517 highlighted.

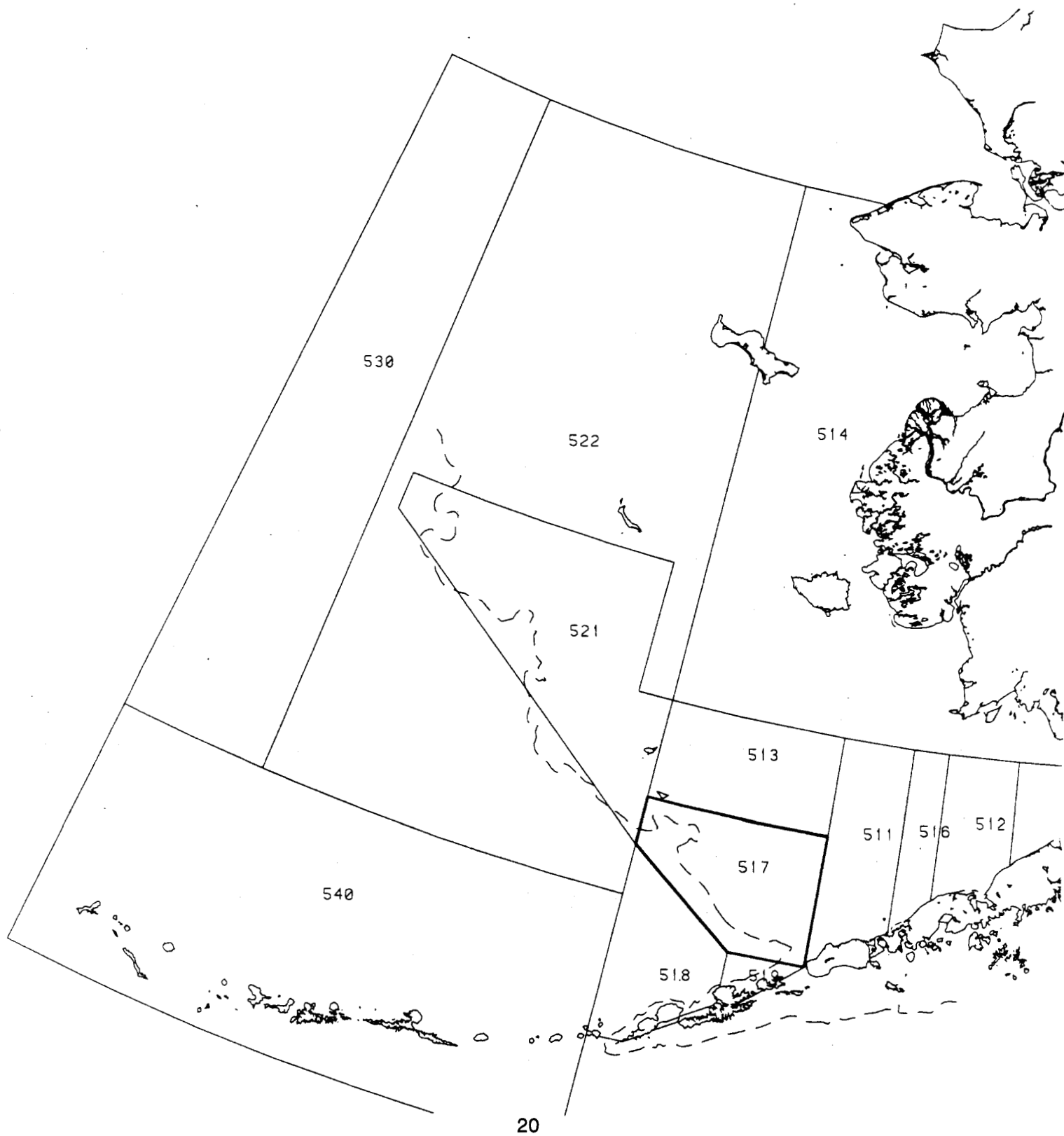


Figure 4. 9 Block Alternative shaded, CVOA highlighted.

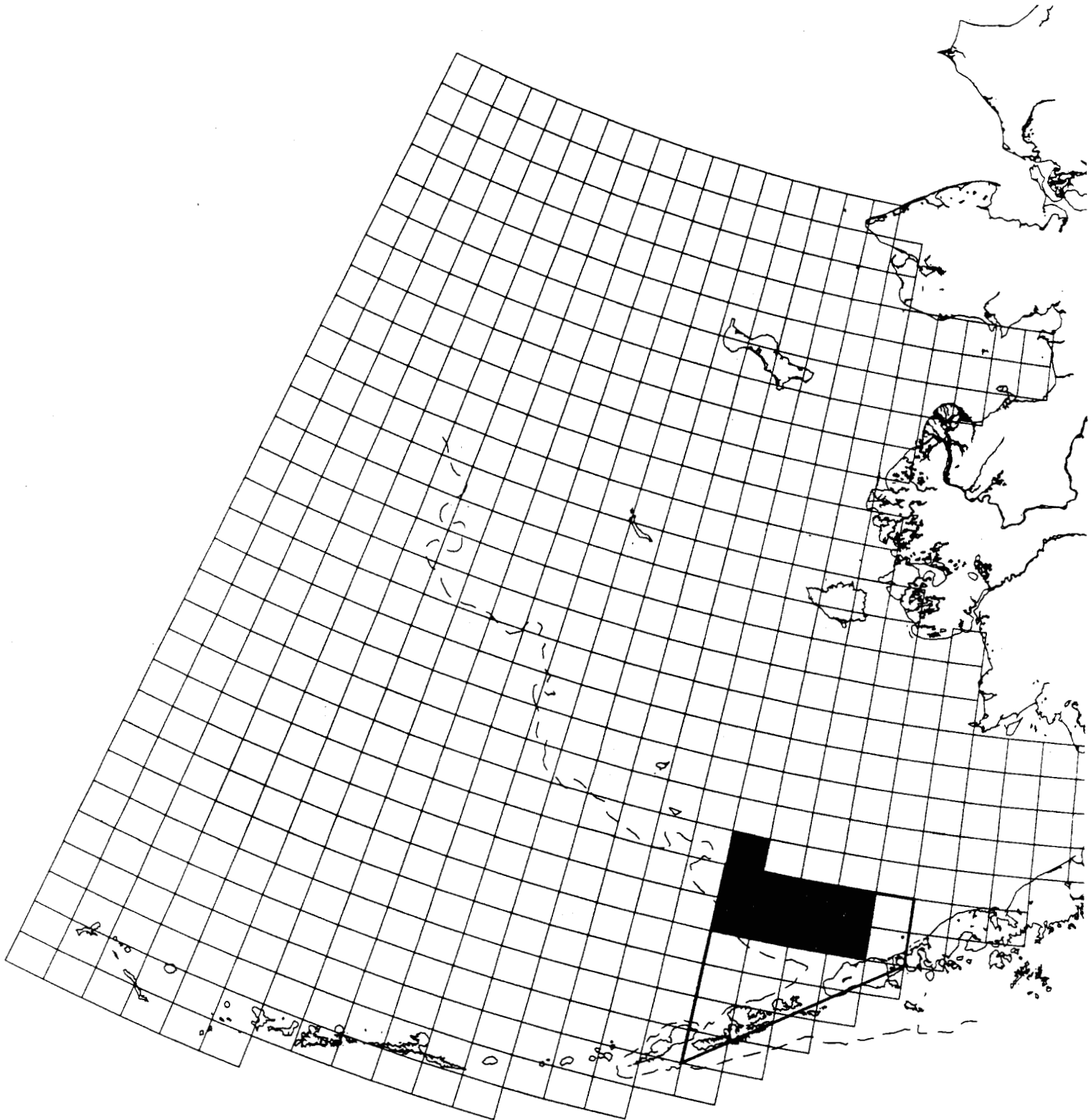


Figure 5. 5 Block Alternative shaded, CVOA highlighted.

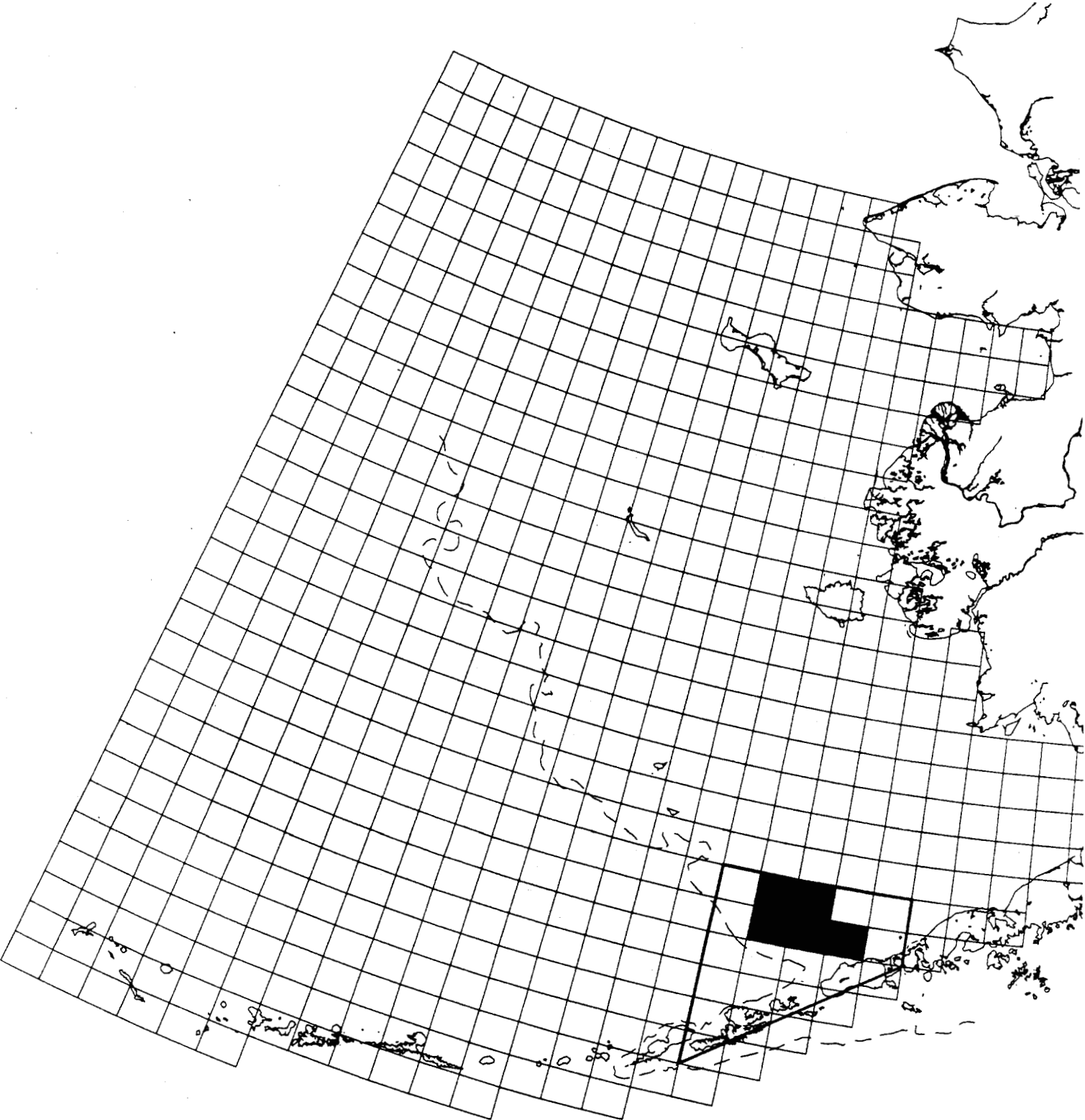


Figure 6. 7 Block Alternative shaded, CVOA highlighted.

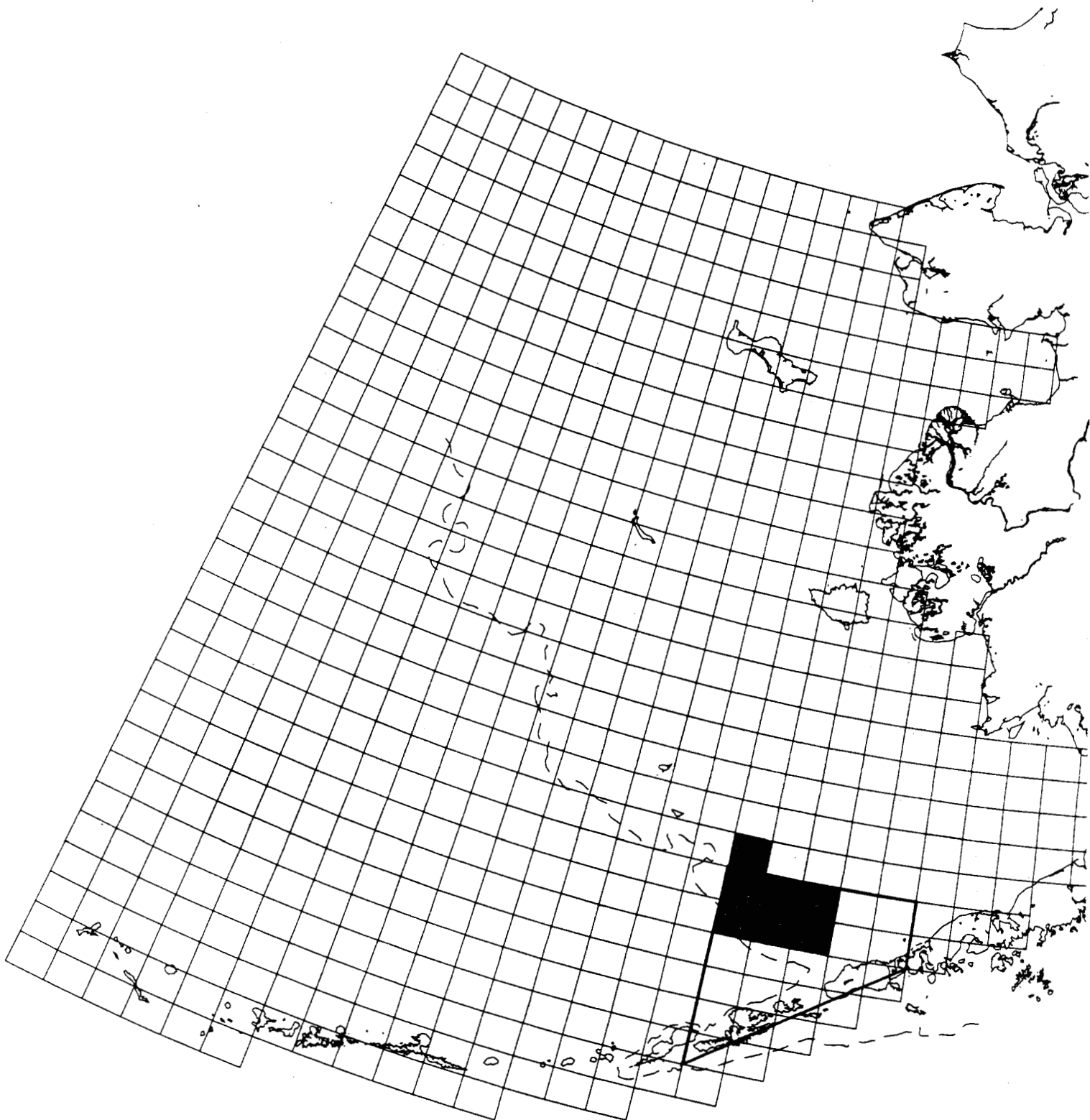


Figure 7.

Annual species composition of foreign and Joint Venture trawl fisheries bycatch as published by NMFS. Horizontal axis is the percentage of all salmon which are chinook, and the vertical axis is the percentage of the remaining other salmon which are chum salmon.

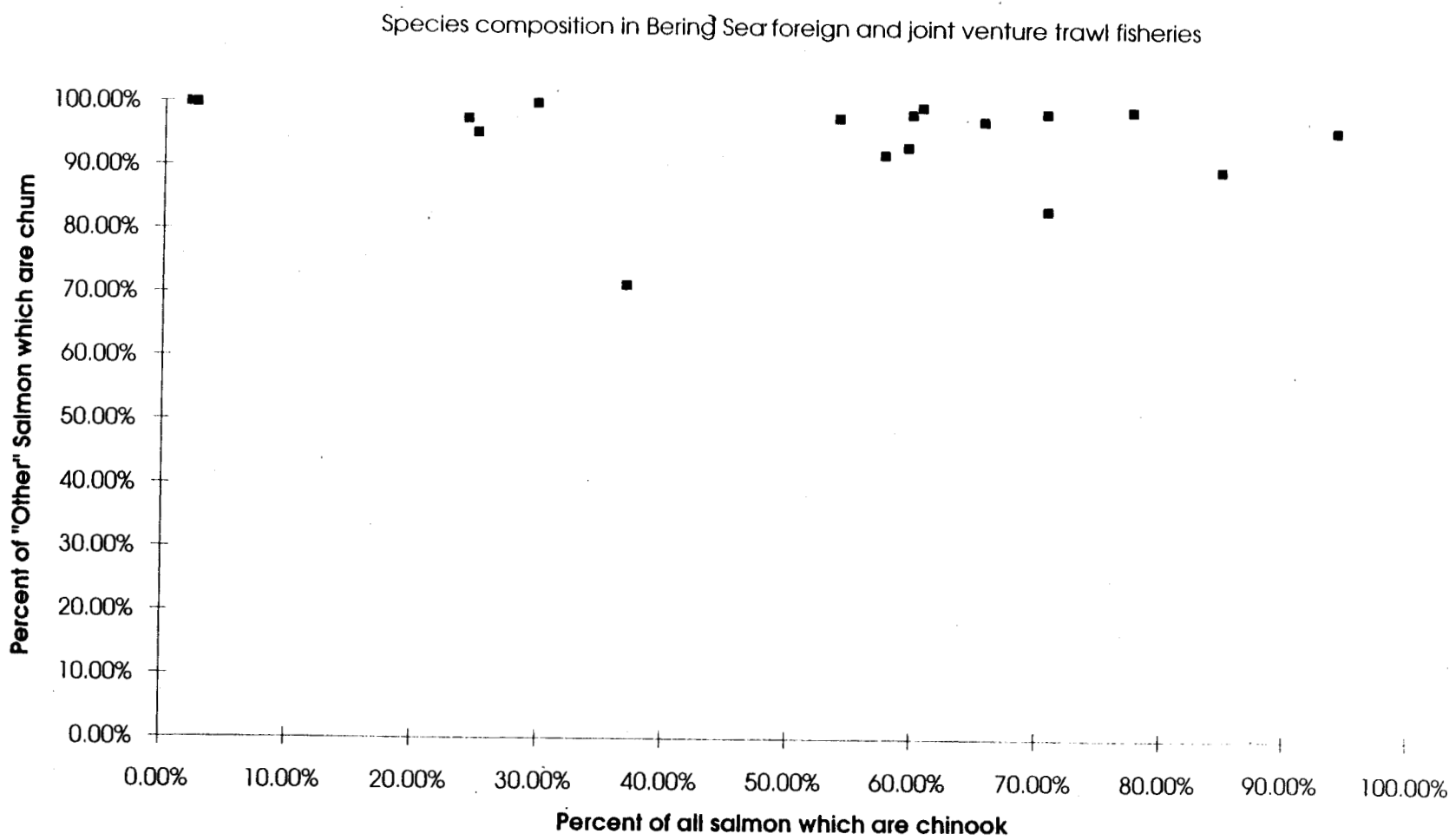


Figure 8.

Annual commercial chum salmon catch in directed fisheries, 1980-1993. AYK= Kotzebue, Norton Sound, Yukon and Kuskokwim. Westward = Chignik, Kodiak, and Alaska Peninsula/Aleutians. Central= Prince William Sound, Cook Inlet, and Bristol Bay. Southeast= southeast AK.

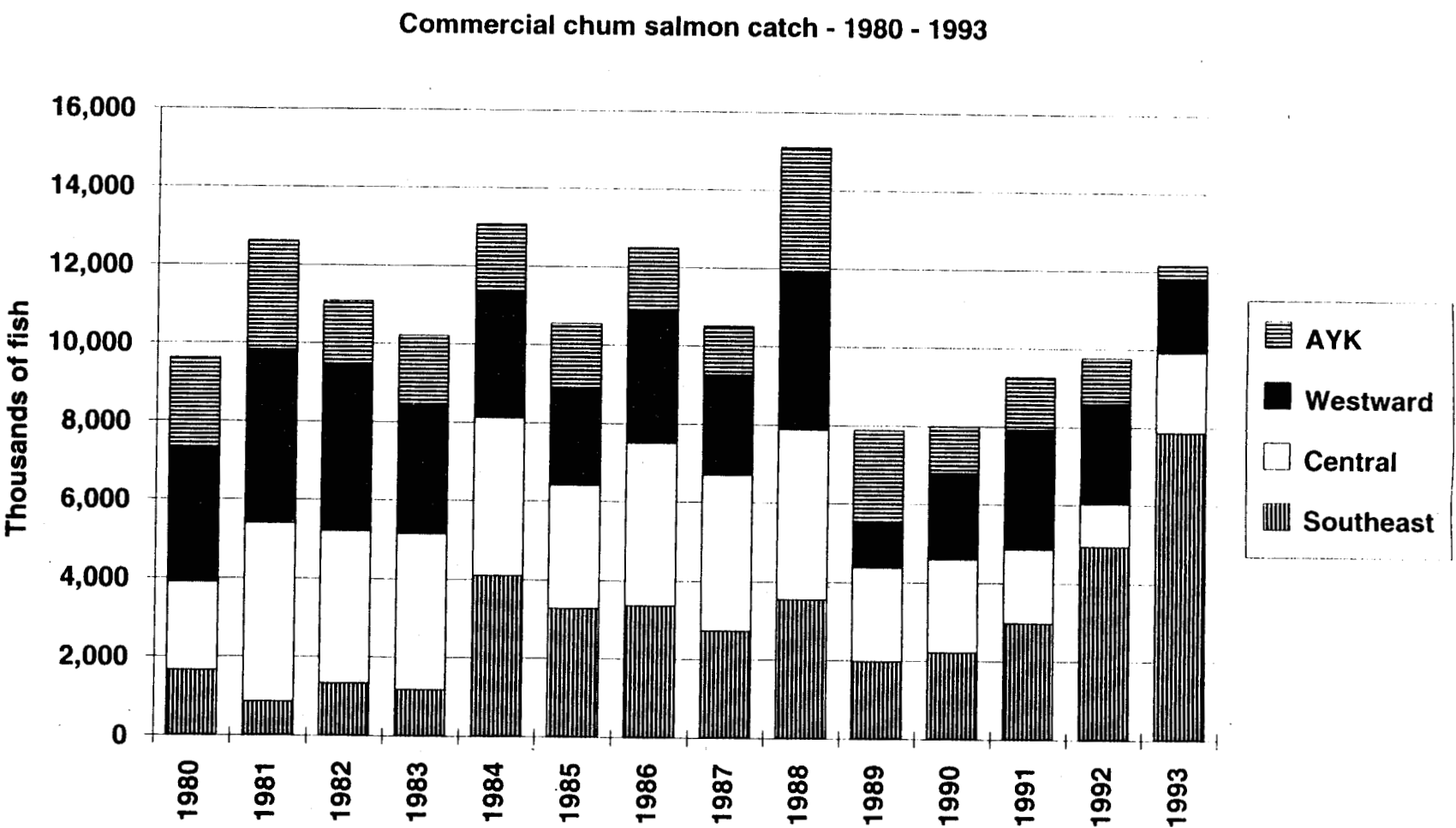


Figure-9. Total estimated bycatch of chum/other salmon from NMFS observer reports. Foreign and JV fisheries predominate in 1980-1989, and domestic fisheries are represented in 1990-1993.

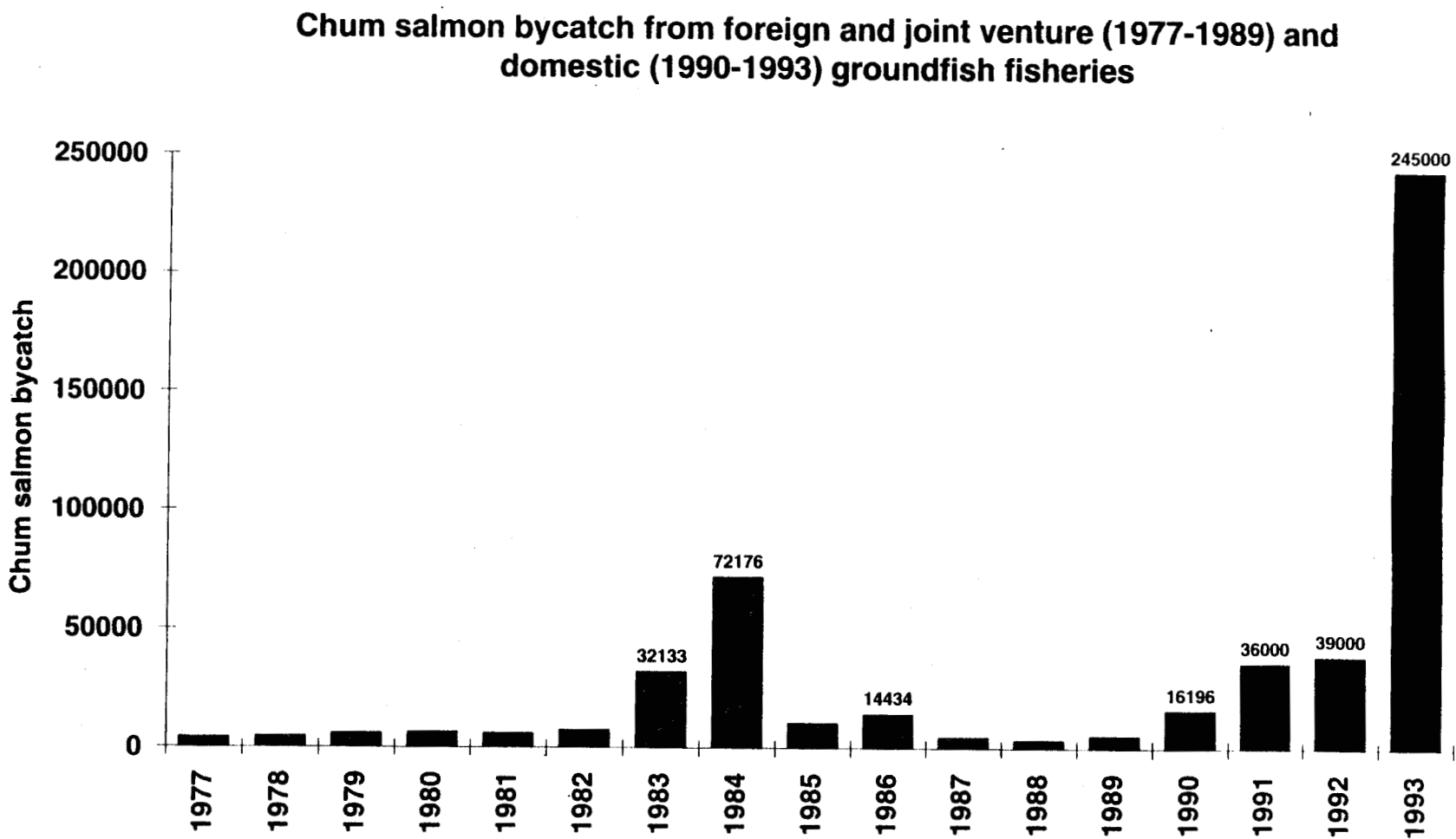


Figure 10. Top: Percentage of annual other salmon bycatch by month from observed hauls only 1990-1993. Bottom: Mean other salmon bycatch rate as per vessel bycatch per metric ton of groundfish catch.

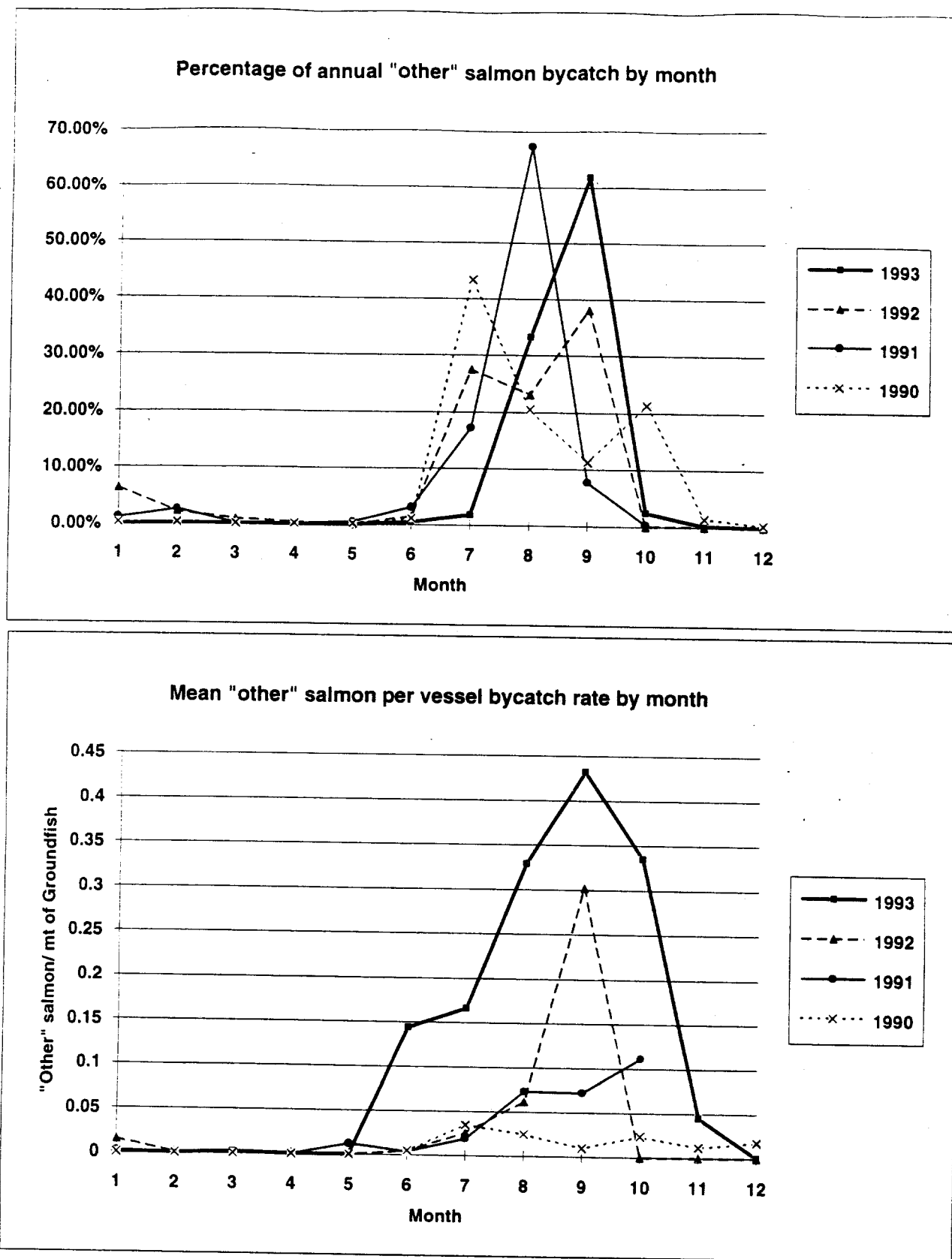


Figure 11. Top: Percentage of annual number of hauls by month from observed vessels only 1990-1993. Bottom: Percentage of total annual groundfish catch by month from observed vessels only, 1990-1993.

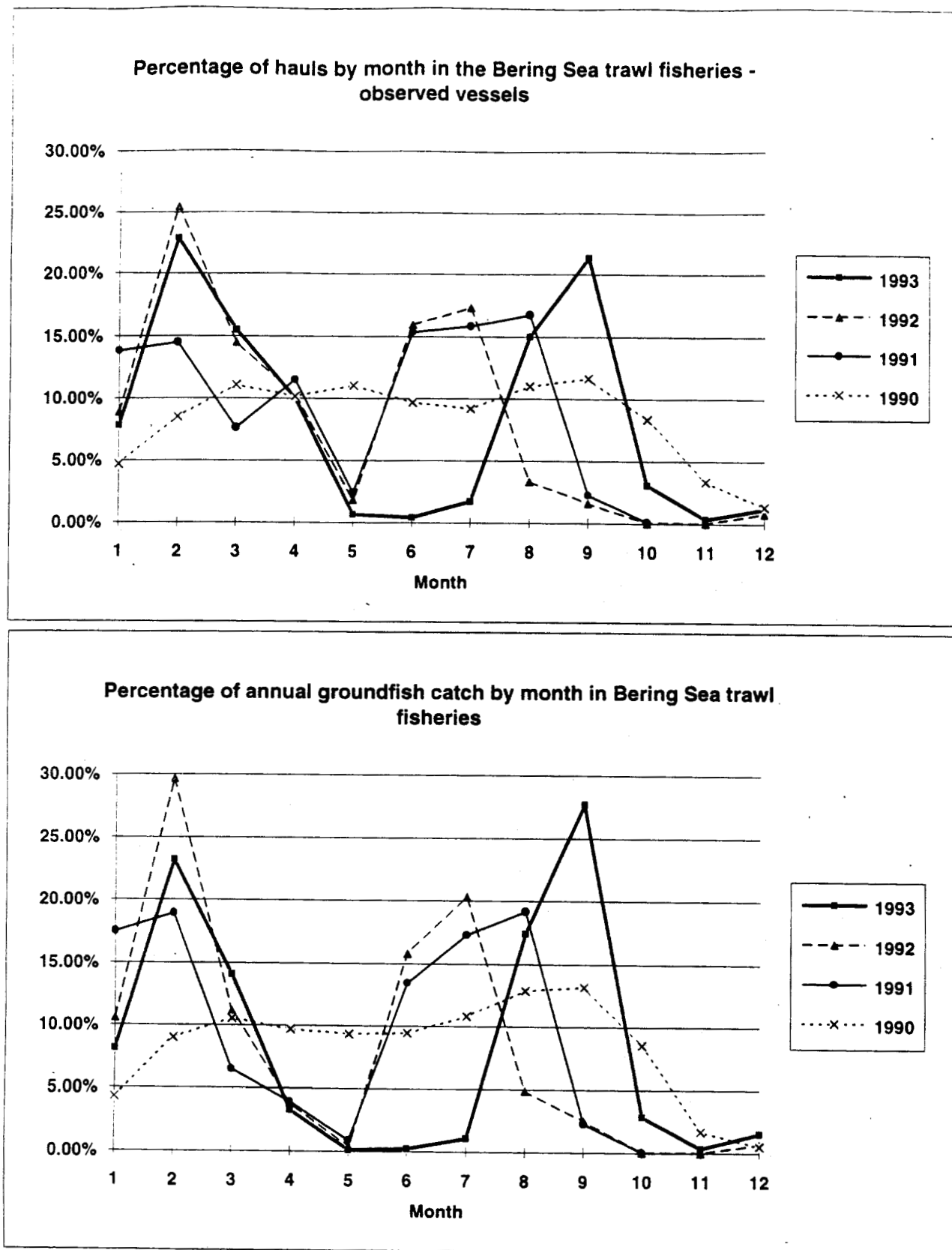


Figure 12. Top: Percentage of total annual chinook bycatch by month from observed vessels only 1990-1993. Bottom: Mean chinook salmon bycatch rate as per vessel bycatch per metric ton of groundfish catch.

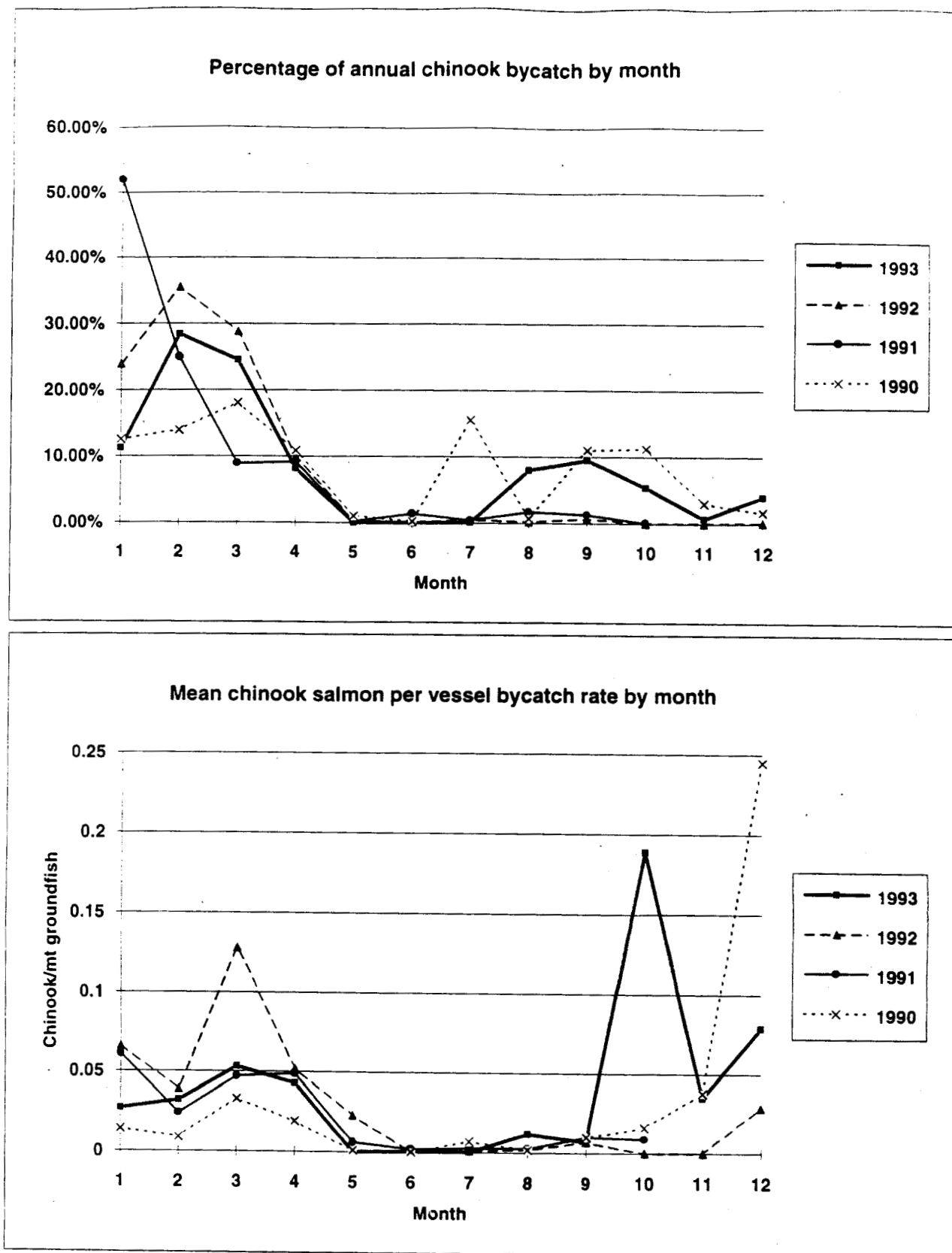


Figure 13. Bycatch of other salmon from observed hauls in 1990. Horizontal axes are the longitude and latitude locations of the observed hauls.

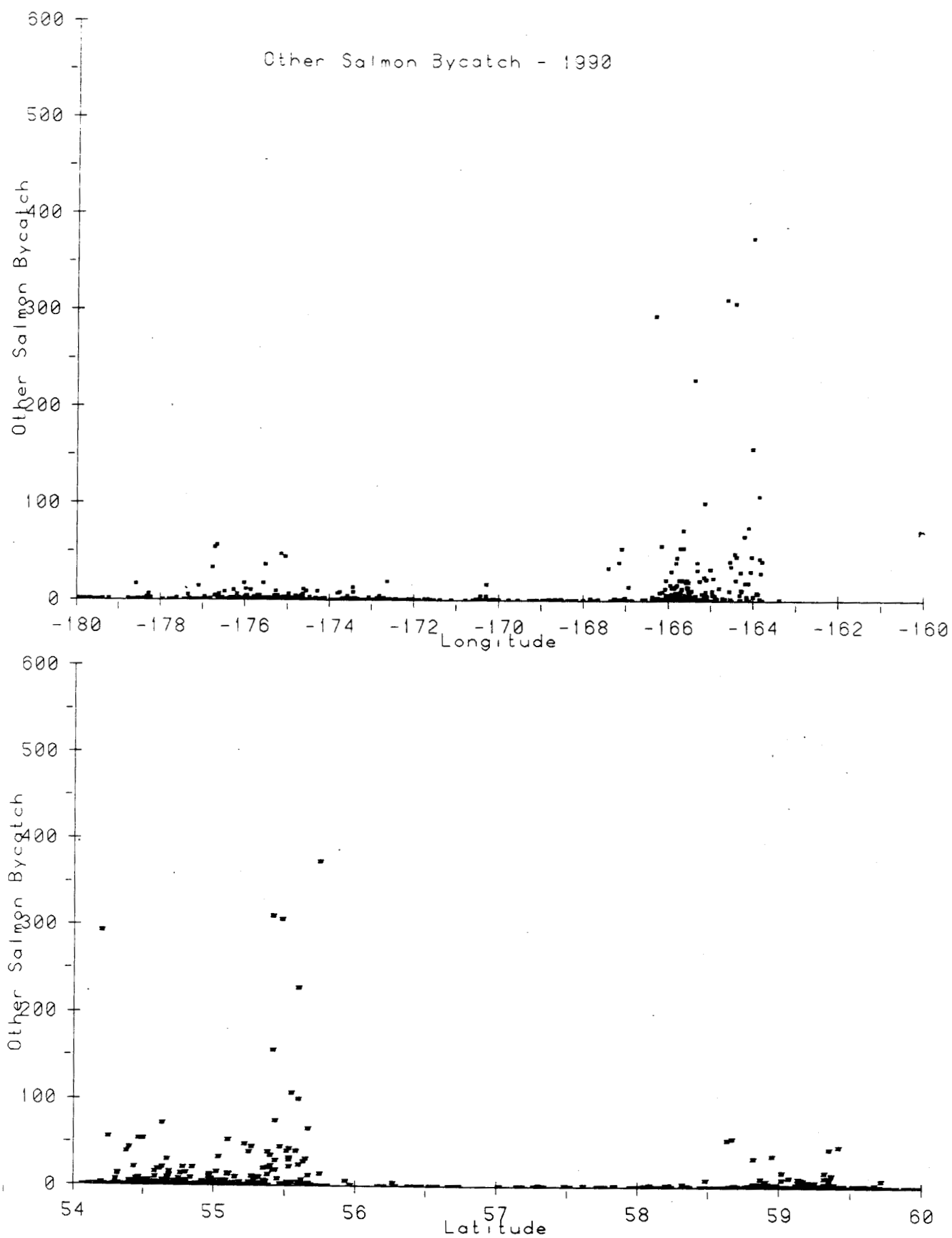


Figure 14. Bycatch of other salmon from observed hauls in 1991. Horizontal axes are the longitude and latitude locations of the observed hauls.

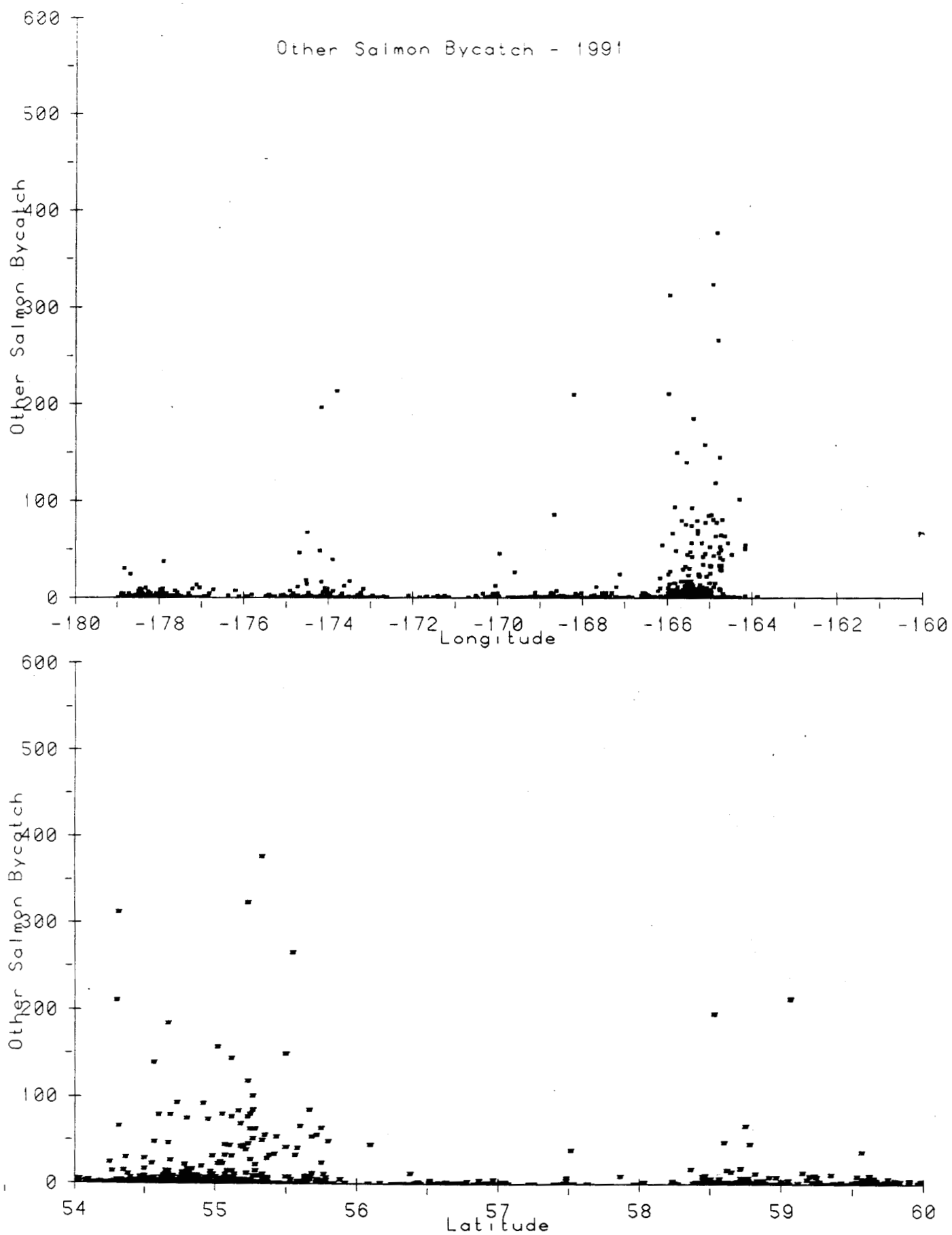


Figure 15. Bycatch of other salmon from observed hauls in 1992. Horizontal axes are the longitude and latitude locations of the observed hauls.

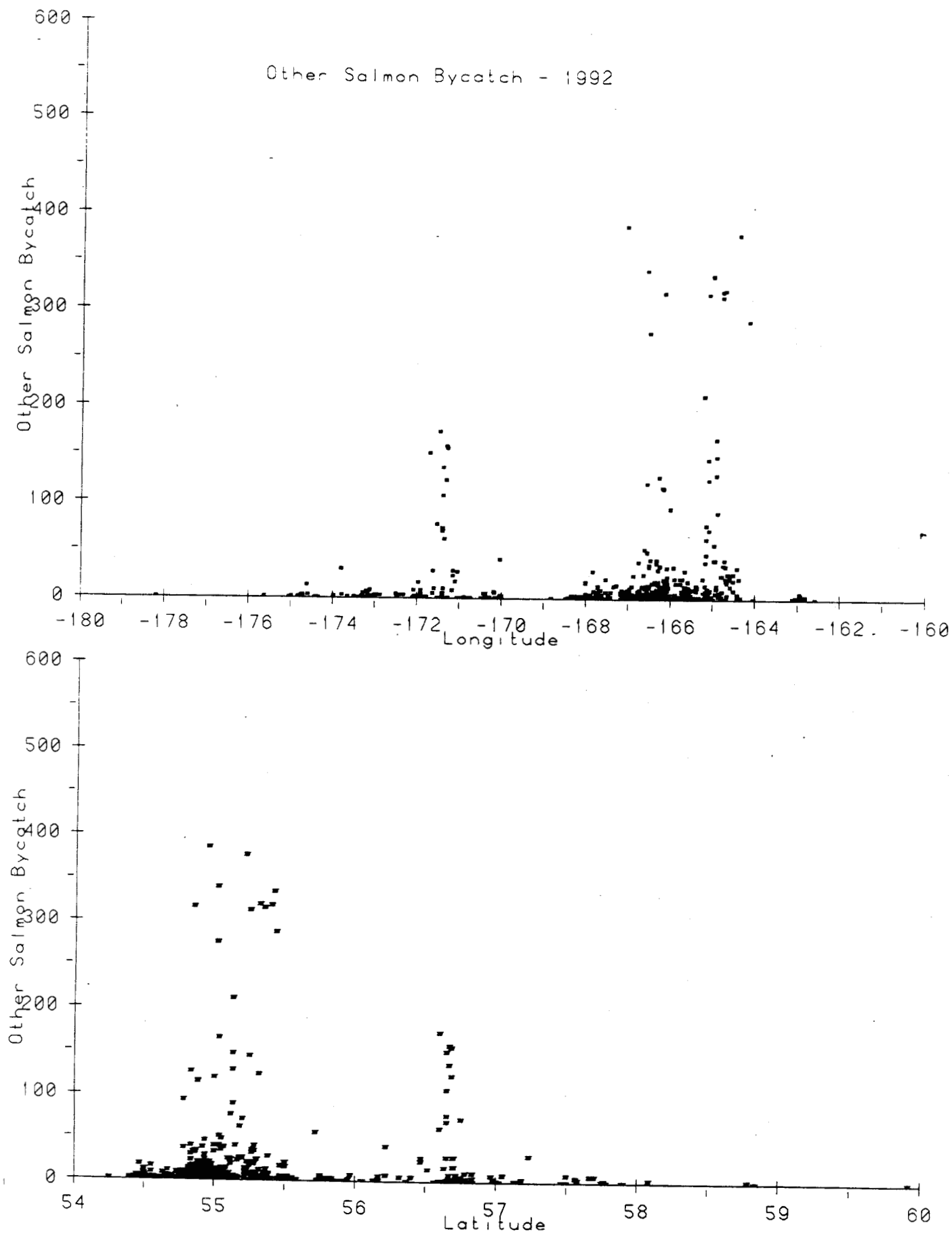


Figure 16.

Bycatch of other salmon from observed hauls in 1993. Horizontal axes are the longitude and latitude locations of the observed hauls.

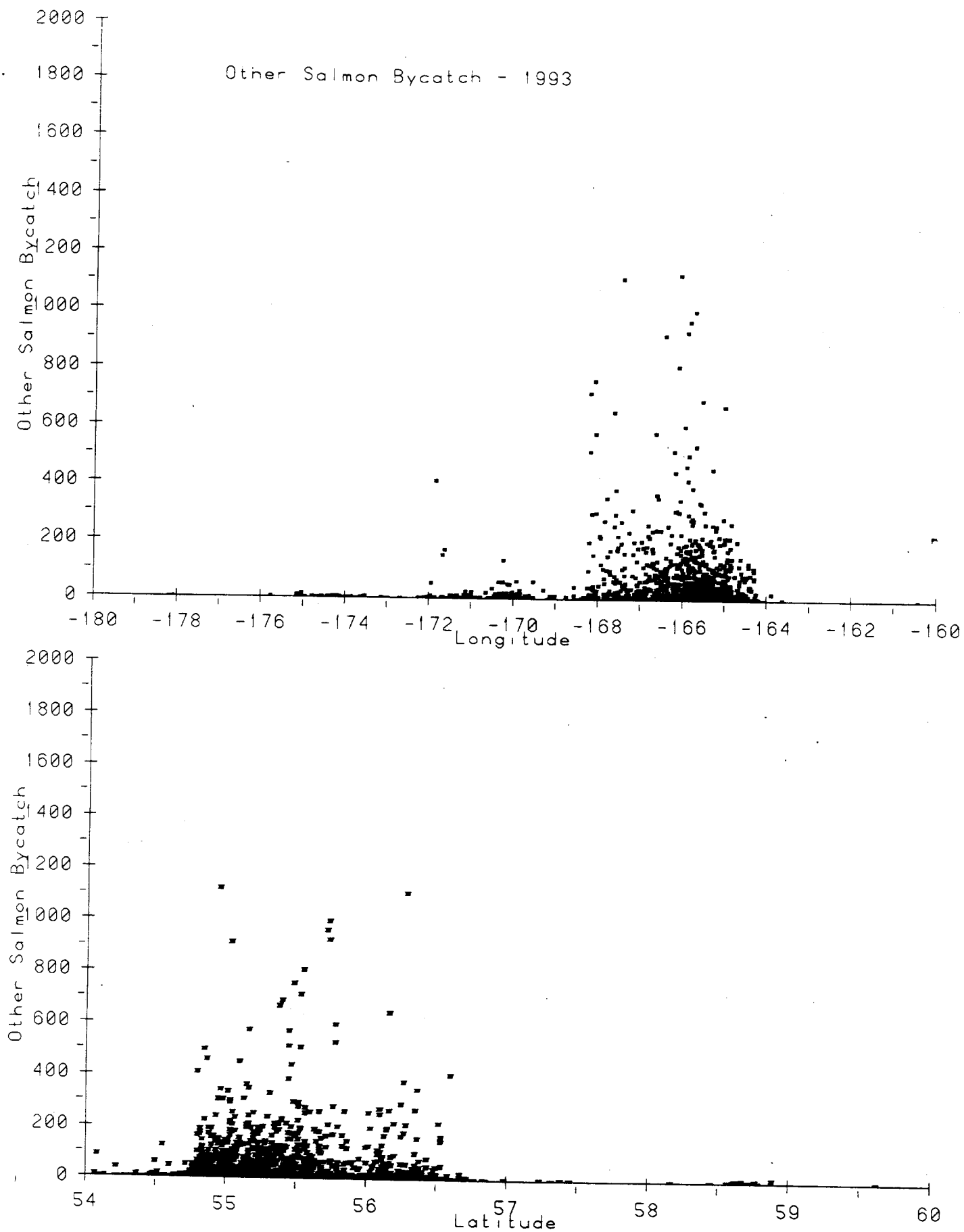


Figure 17. Bycatch of chinook salmon from observed hauls in 1990. Horizontal axes are the longitude and latitude locations of the observed hauls.

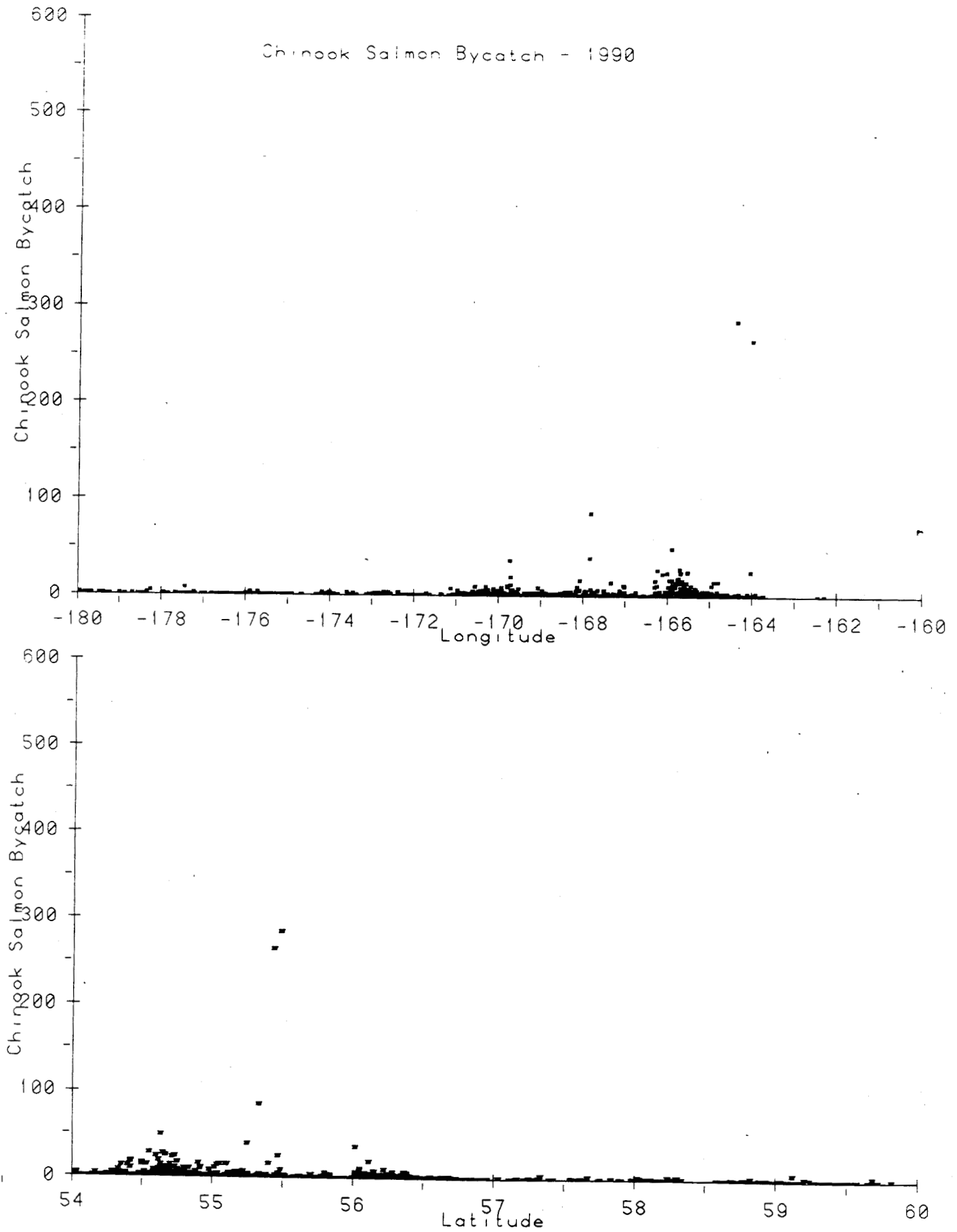


Figure 18. Bycatch of chinook salmon from observed hauls in 1991. Horizontal axes are the longitude and latitude locations of the observed hauls.

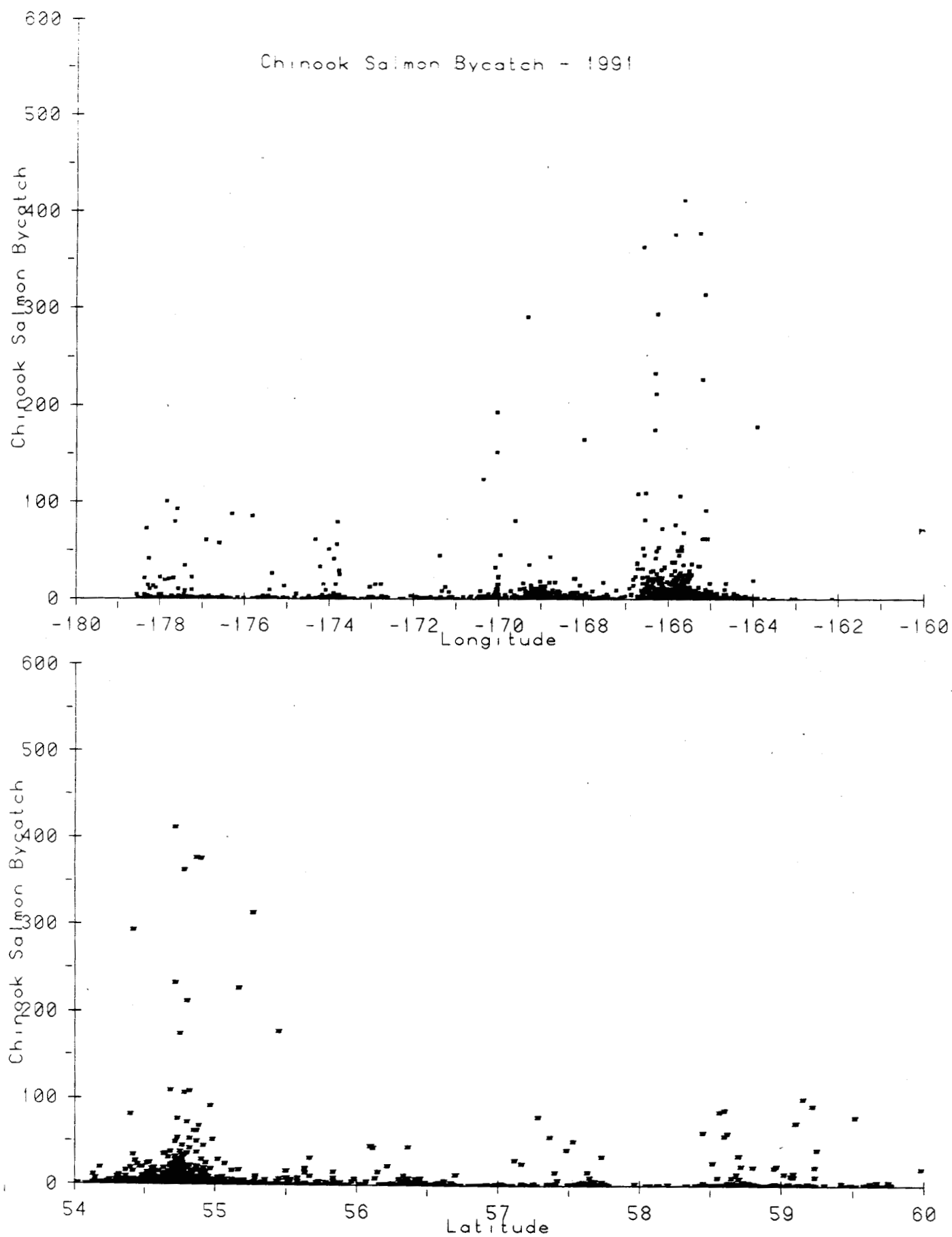


Figure 19. Bycatch of chinook salmon from observed hauls in 1992. Horizontal axes are the longitude and latitude locations of the observed hauls.

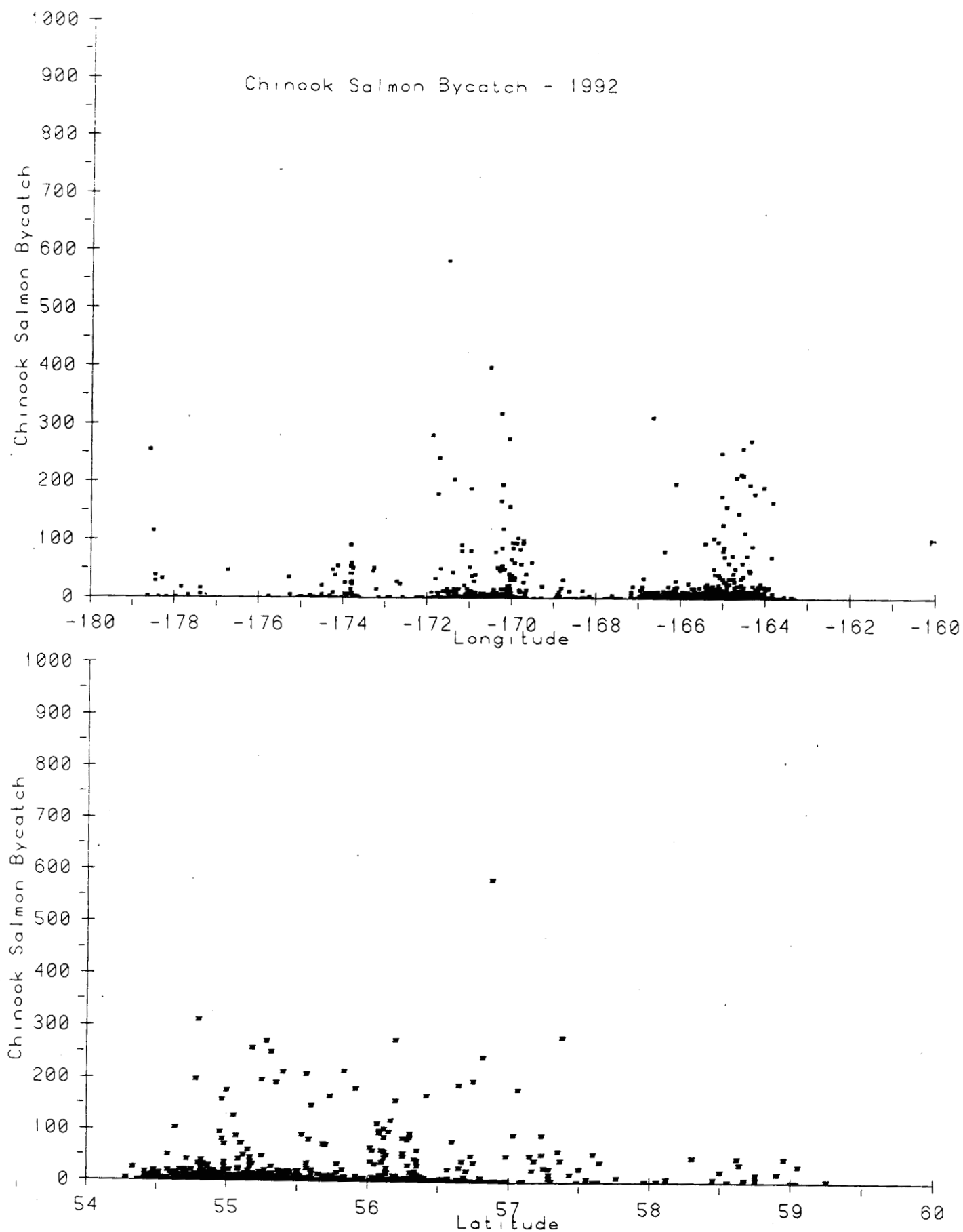


Figure 20. Bycatch of chinook salmon from observed hauls in 1993. Horizontal axes are the longitude and latitude locations of the observed hauls.

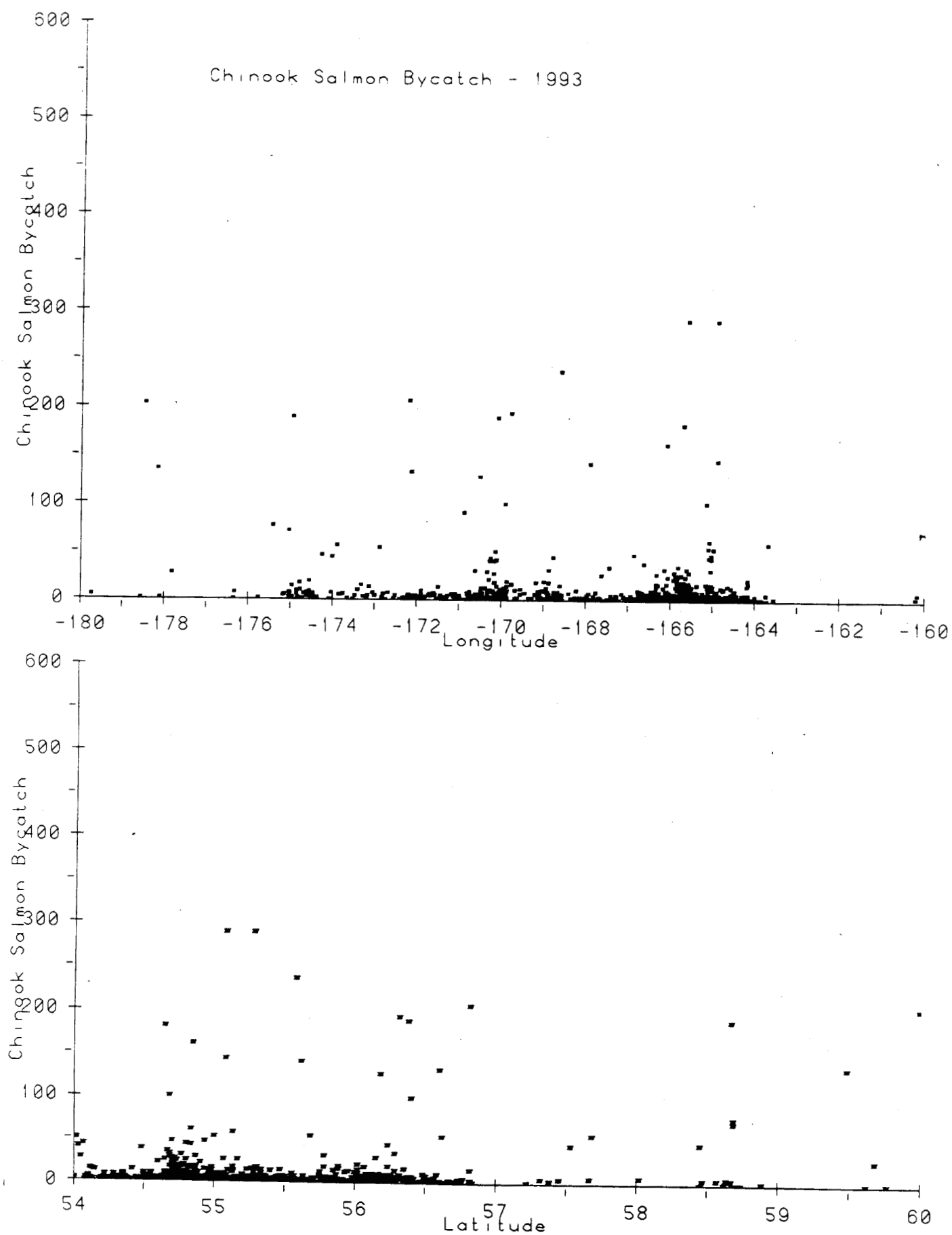


Figure 21.

Outline of main concentration of observed trawls operating in the Bering Sea in 1990 during the months of July through October. Some individual hauls can occur outside of the highlighted areas. 200 m contour a dashed line.

General locations of hauls made in 1990

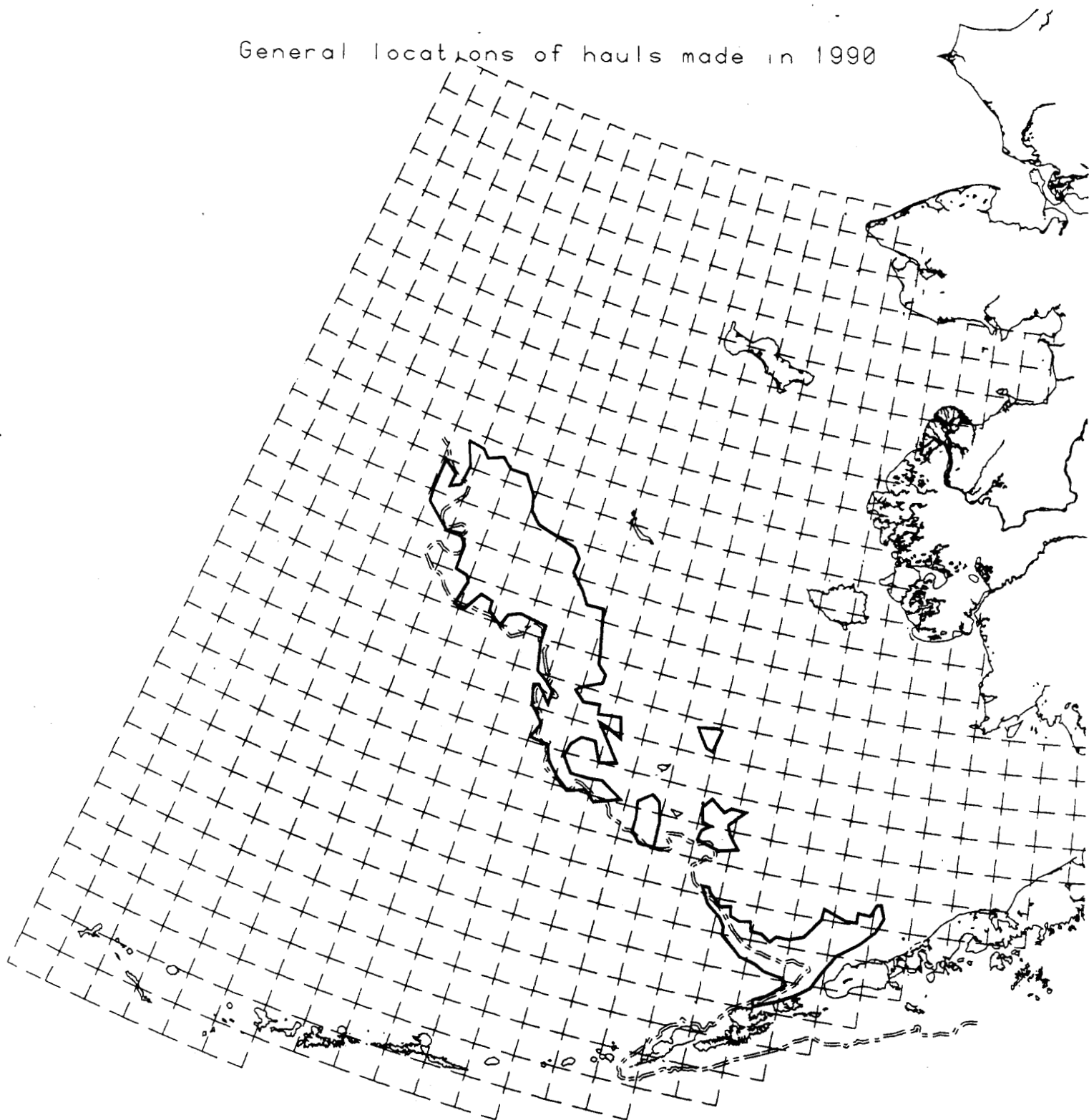


Figure 22.

Location of observed trawls in the Bering Sea during the months of July through October in 1990 with an other salmon bycatch of more than 50 fish. The CVOA is highlighted and the 200 m contour is a dashed line.

July - October 1990, hauls with >50 other salmon

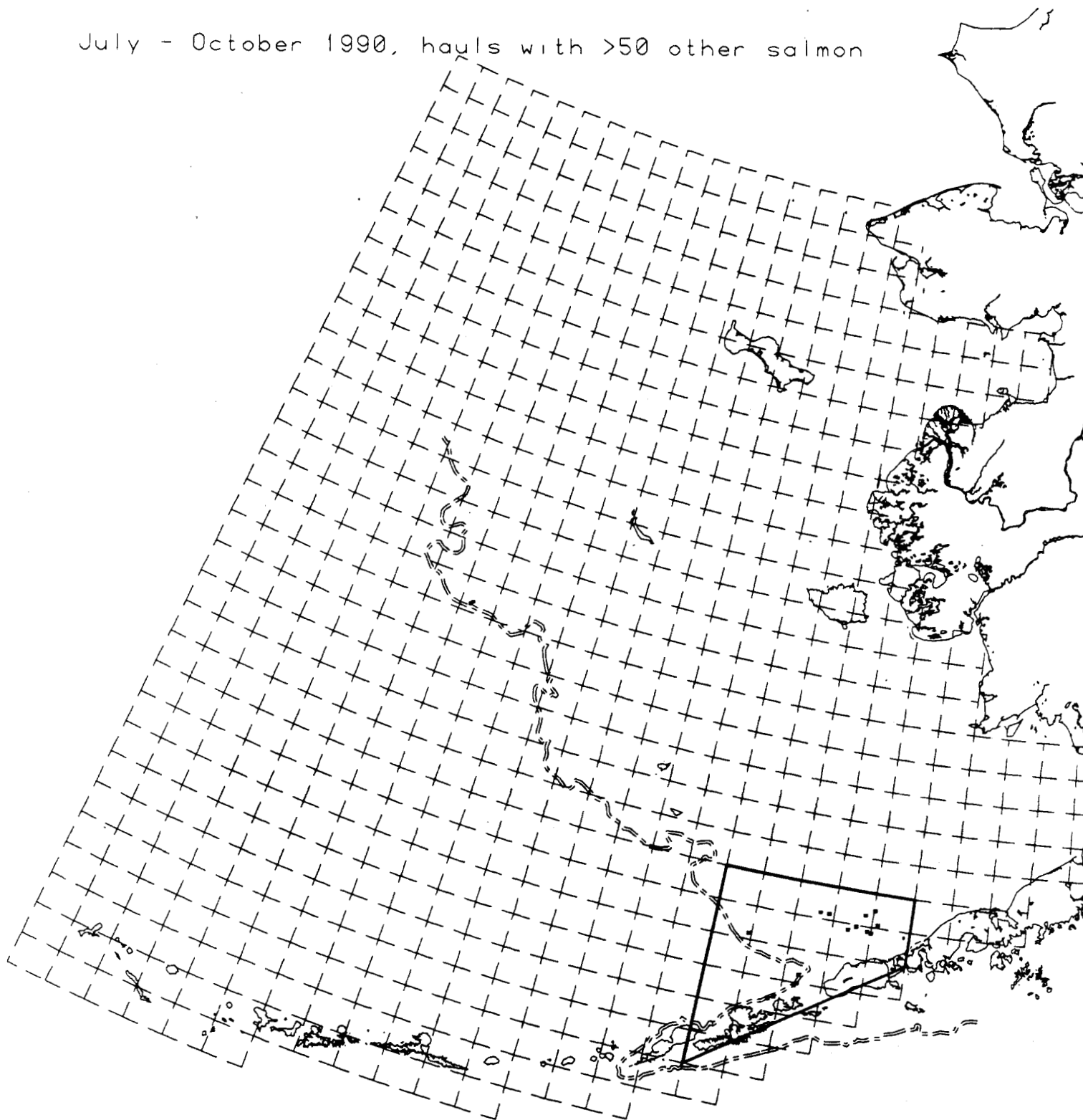


Figure 23.

Outline of main concentration of observed trawls operating in the Bering Sea in 1991 during the months of July through October. Some individual hauls can occur outside of the highlighted areas. 200 m contour a dashed line.

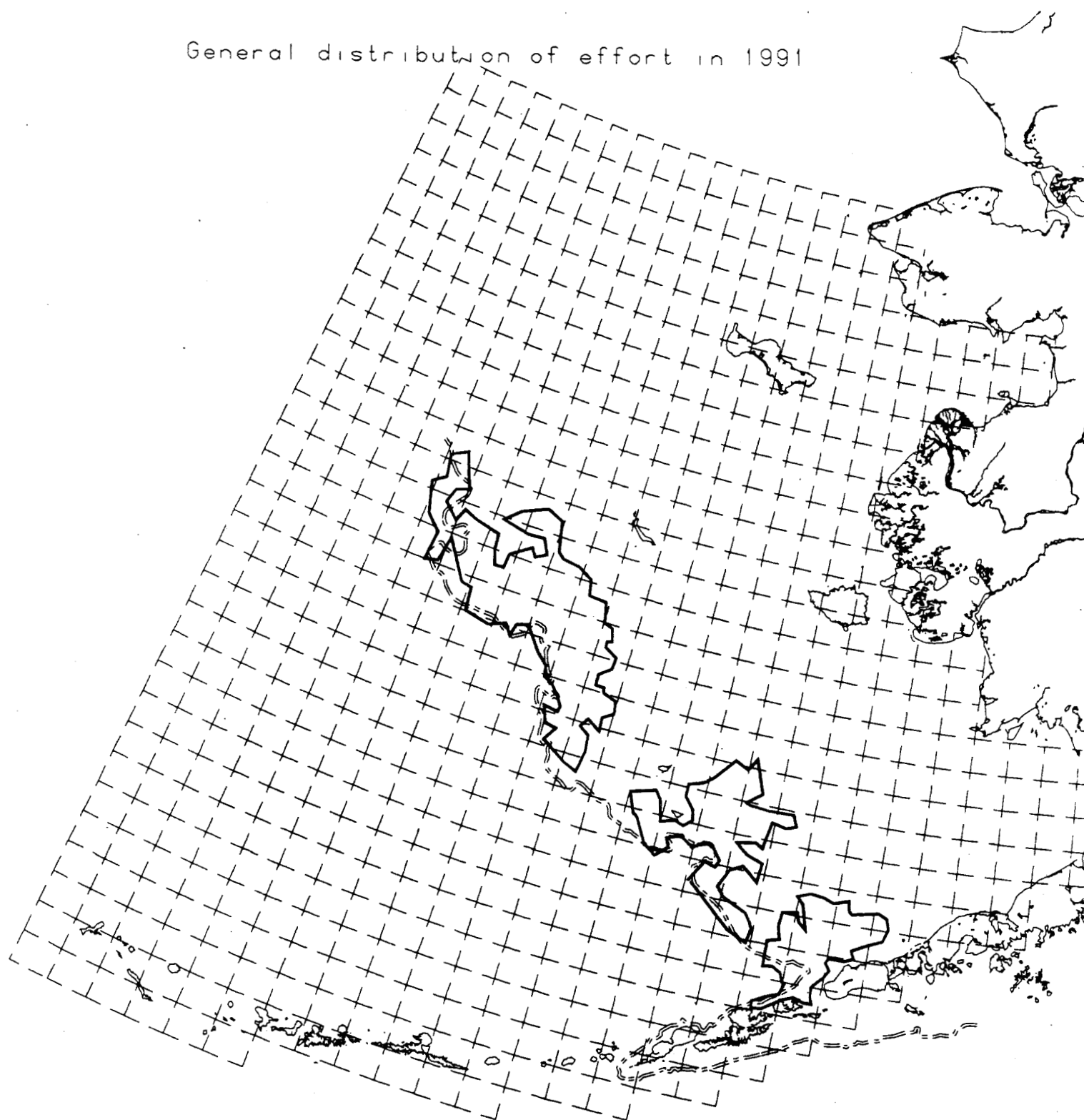


Figure 24. Location of observed trawls in the Bering Sea during the months of July through October in 1991 with an other salmon bycatch of more than 50 fish. The CVOA is highlighted and the 200 m contour is a dashed line.

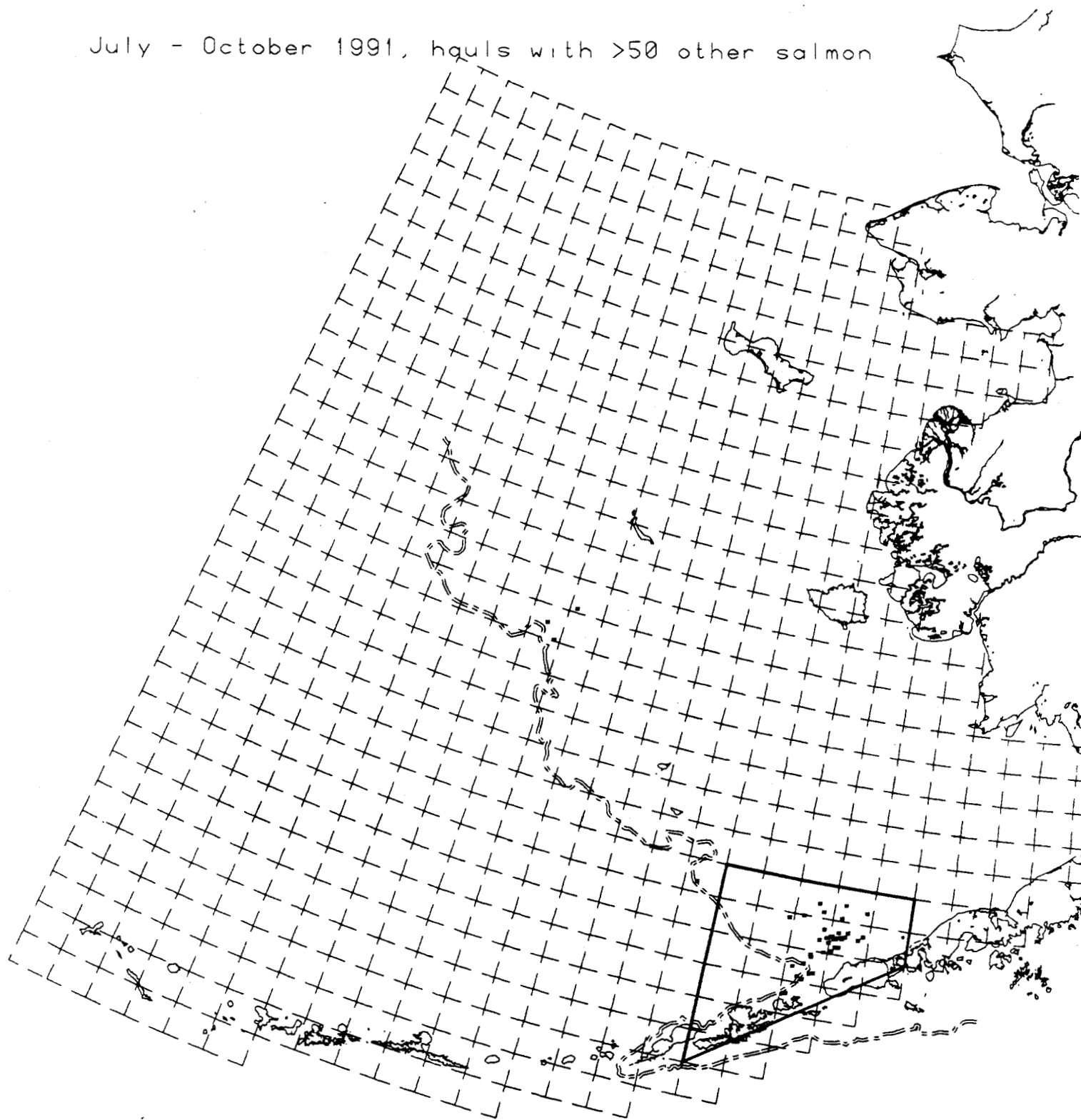


Figure 25.

Outline of main concentration of observed trawls operating in the Bering Sea in 1992 during the months of July through October. Some individual hauls can occur outside of the highlighted areas. 200 m contour a dashed line.

General distribution of effort in 1992

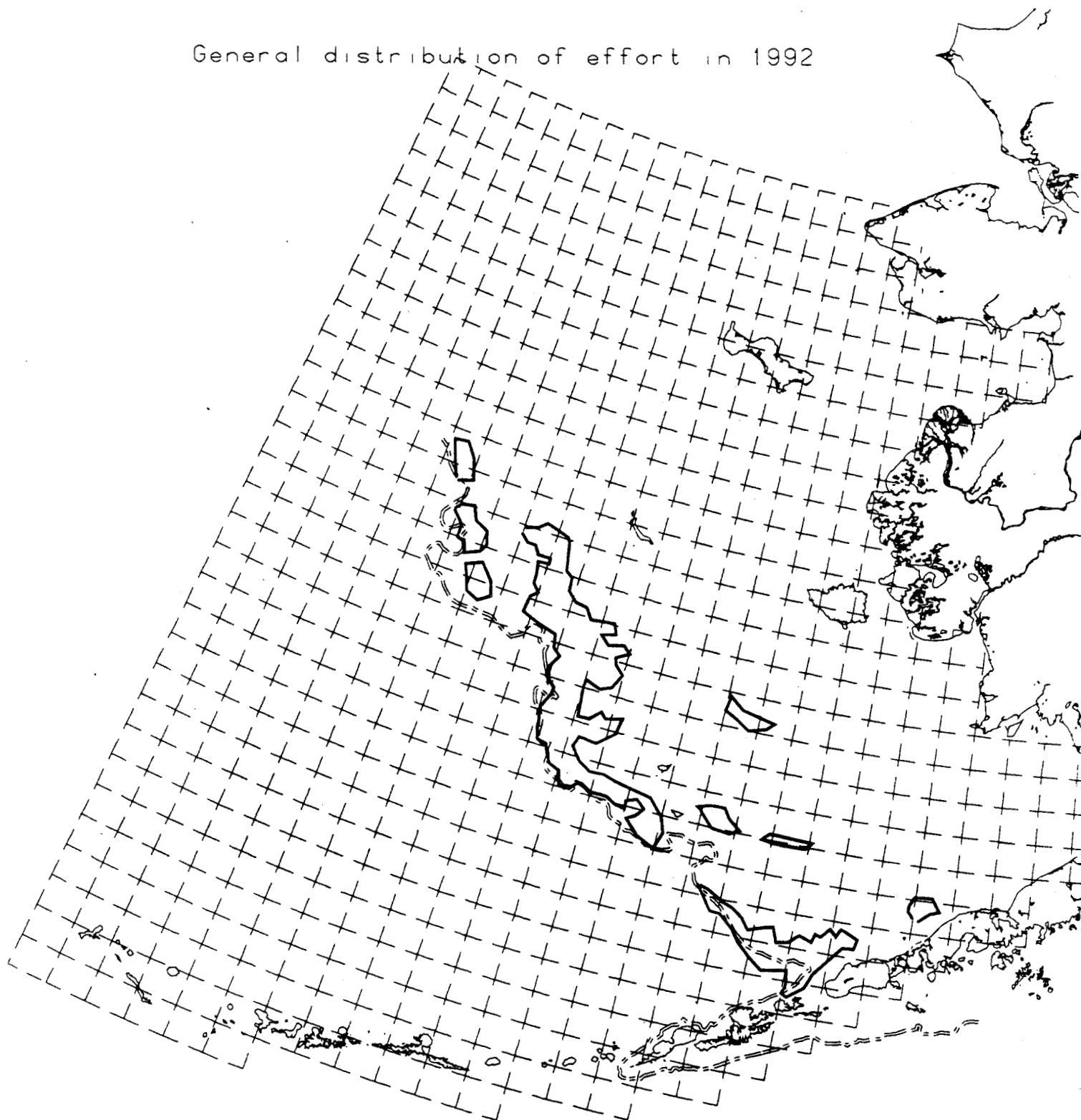


Figure 26. Location of observed trawls in the Bering Sea during the months of July through October in 1992 with an other salmon bycatch of more than 50 fish. The CVOA is highlighted and the 200 m contour is a dashed line.

July - October 1992, hauls with >50 other salmon

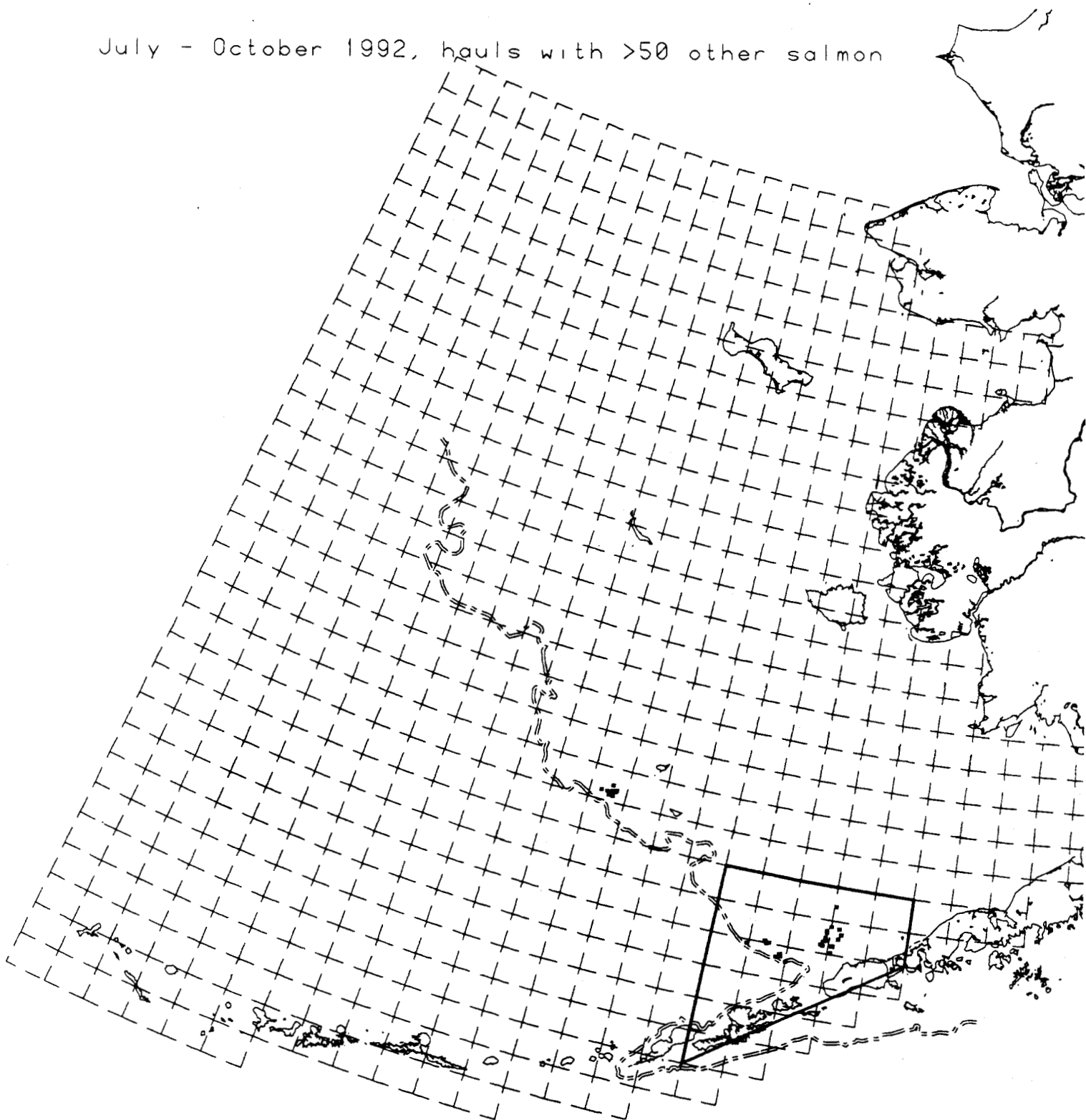


Figure 27.

Outline of main concentration of observed trawls operating in the Bering Sea in 1993 during the months of July through October. Some individual hauls can occur outside of the highlighted areas. 200 m contour a dashed line.

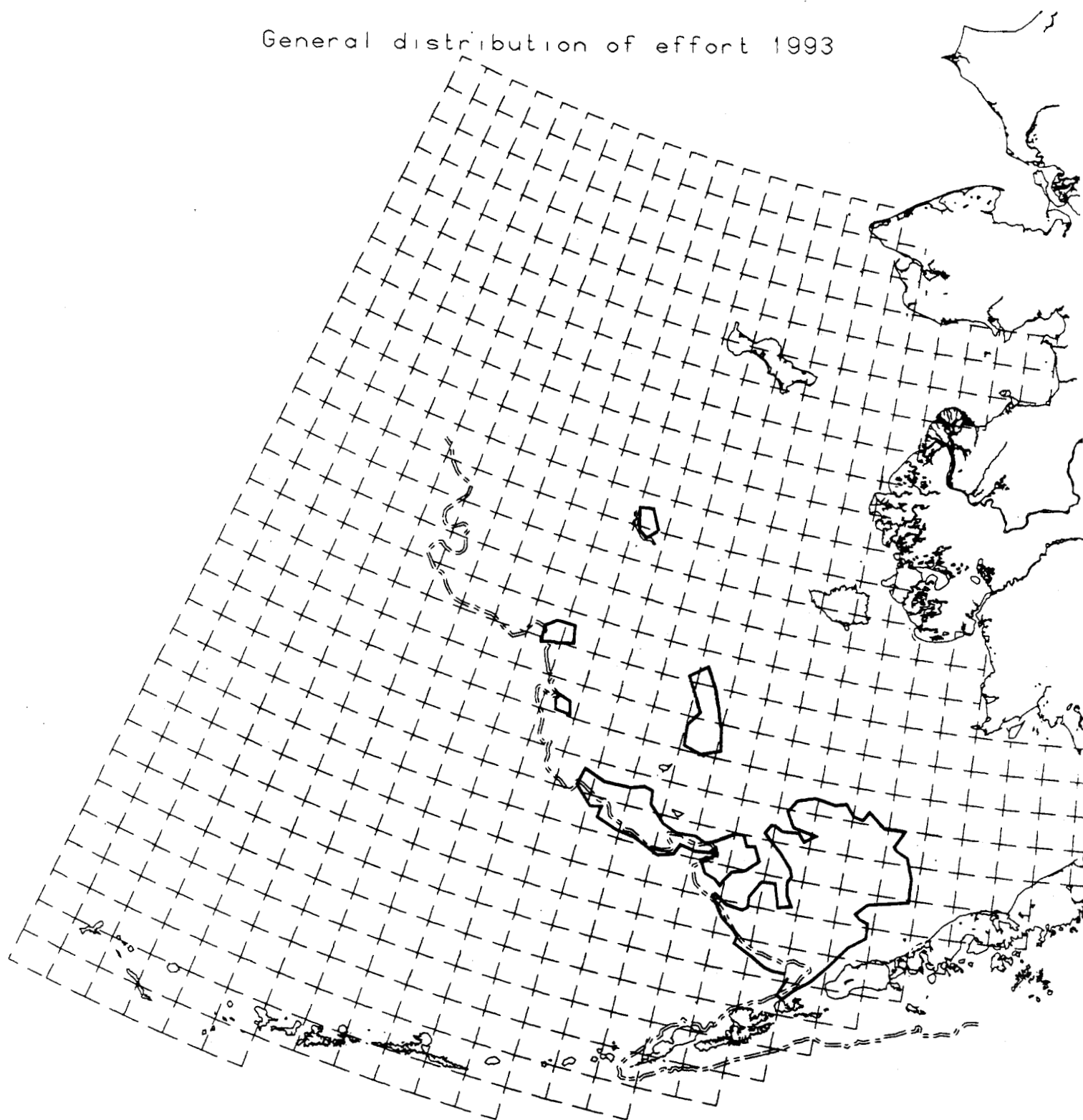


Figure 28.

Location of observed trawls in the Bering Sea during the months of July through October in 1993 with an other salmon bycatch of more than 50 fish. The CVOA is highlighted and the 200 m contour is a dashed line.

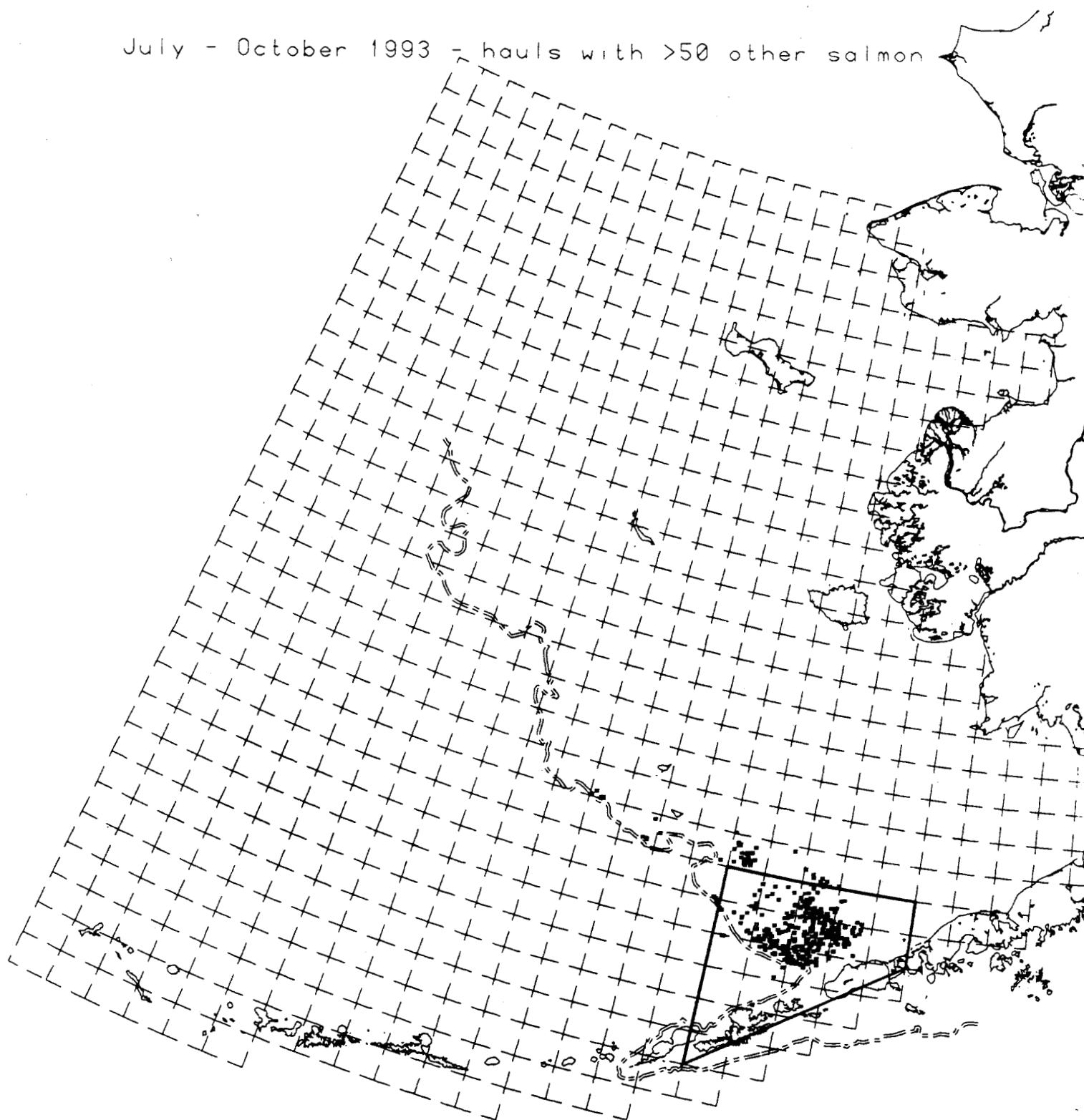


Figure 29. Top: Percentage of total annual groundfish catch from Bering Sea trawl fisheries by alternative areas. Bottom: Groundfish catch taken during the months July through October expressed as a percentage of total annual groundfish catch.

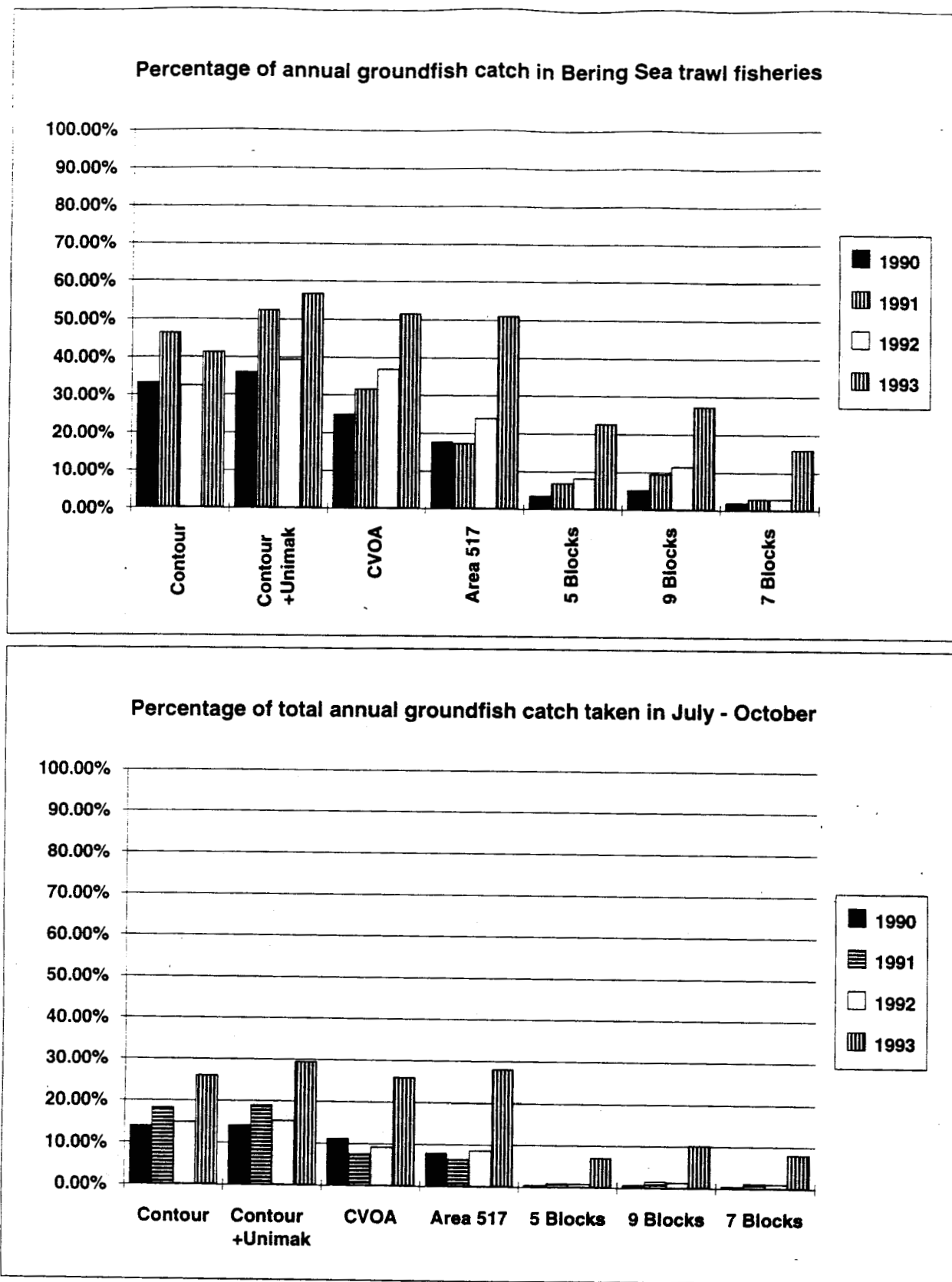


Figure 30. Top: Percentage of total annual other salmon bycatch from Bering Sea trawl fisheries by alternative areas. Bottom: Other salmon bycatch from the months July through October expressed as a percentage of total annual other salmon bycatch.

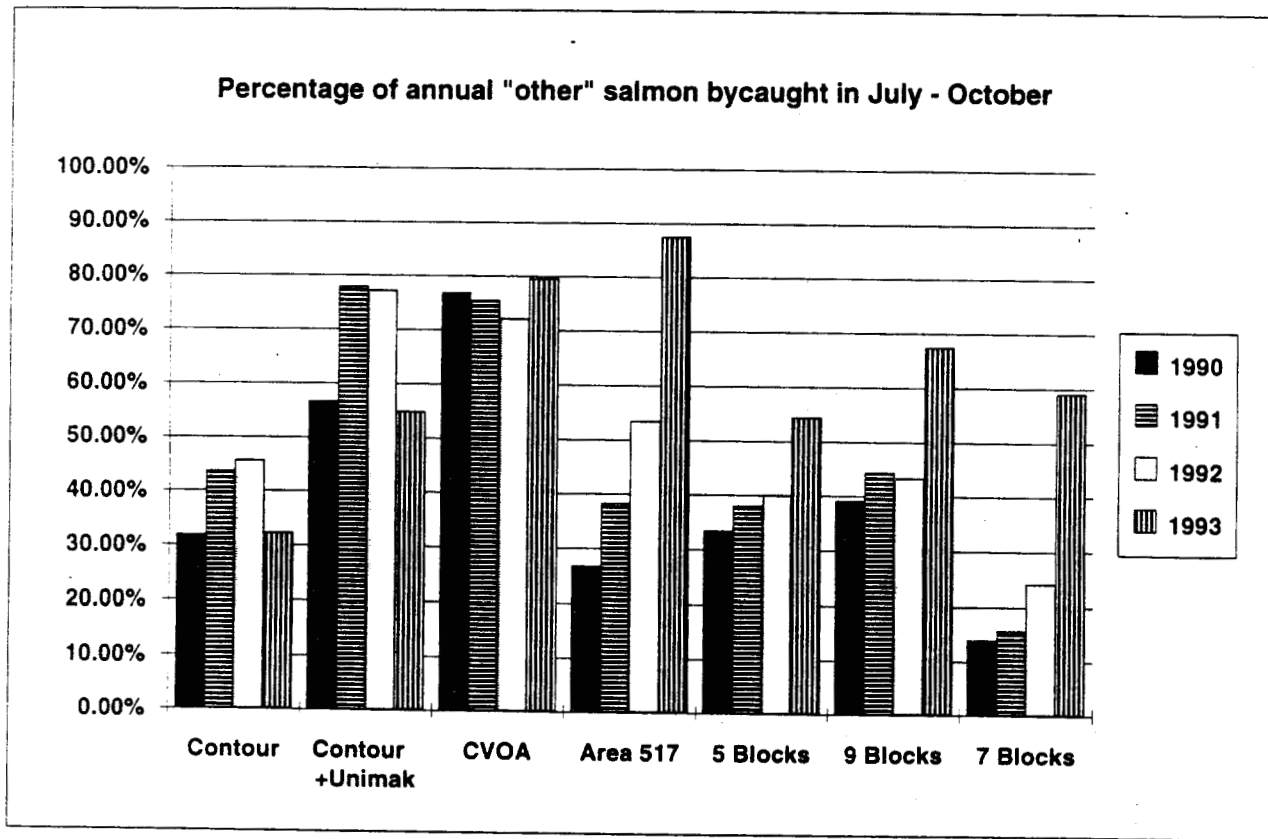
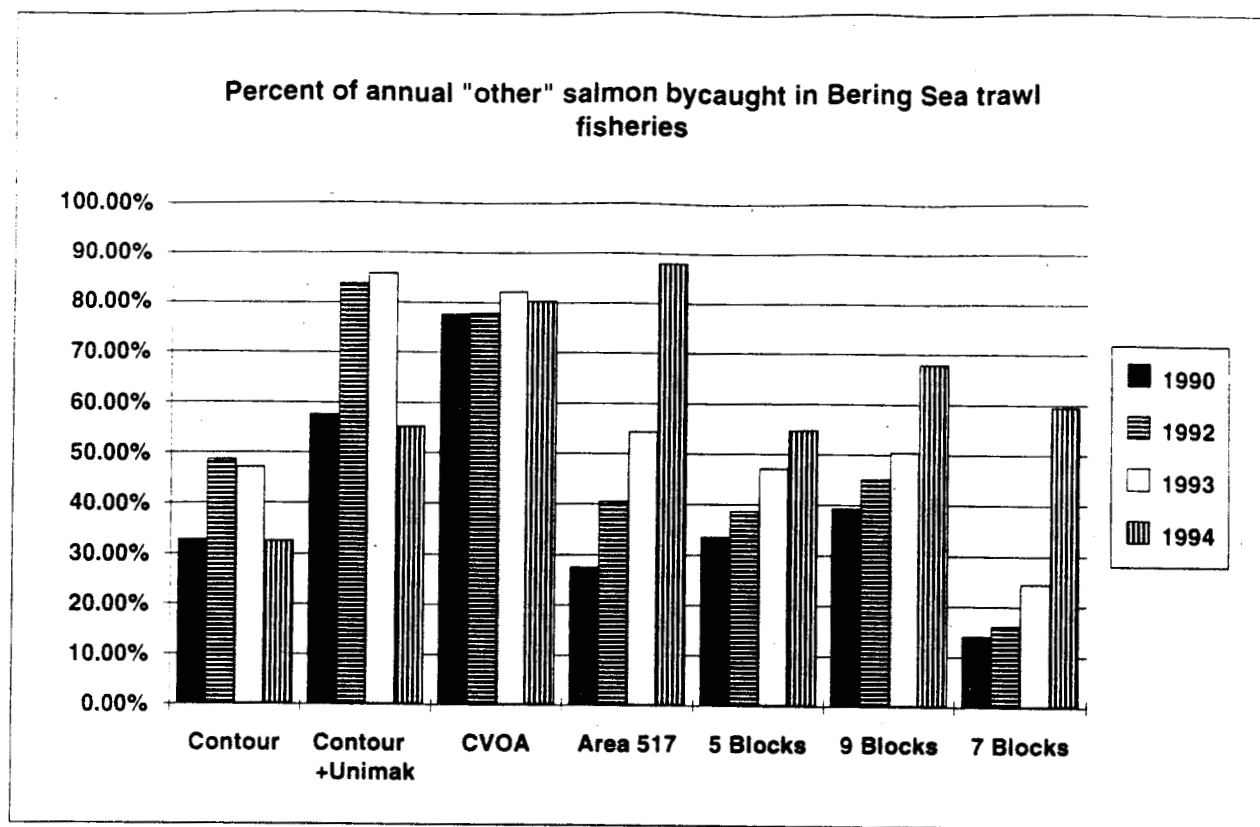


Figure 31. Bering Sea divided into 5 mutually exclusive areas. Top: The percentage of the number of annual hauls from each of 5 non-overlapping areas. Bottom: The percentage of total annual groundfish catch from each of 5 non-overlapping areas.

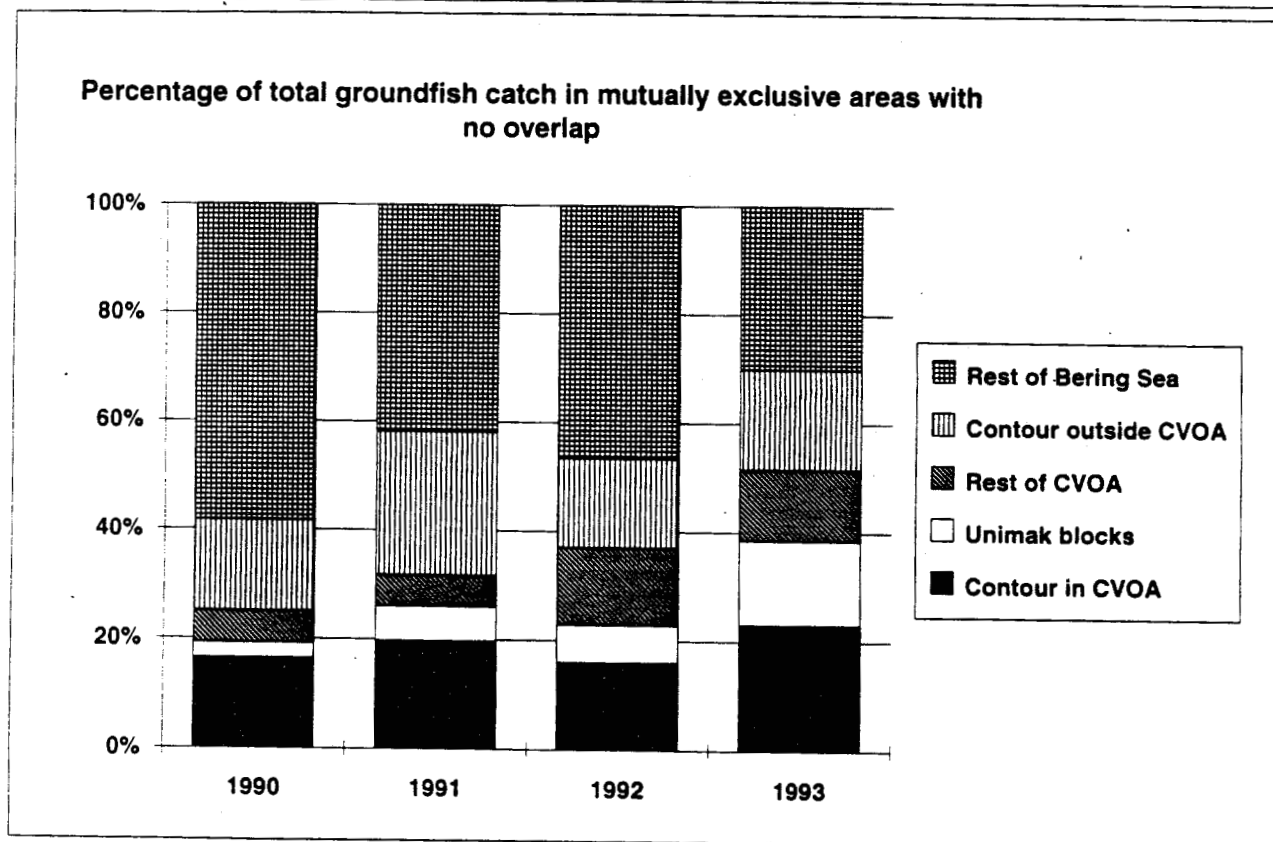
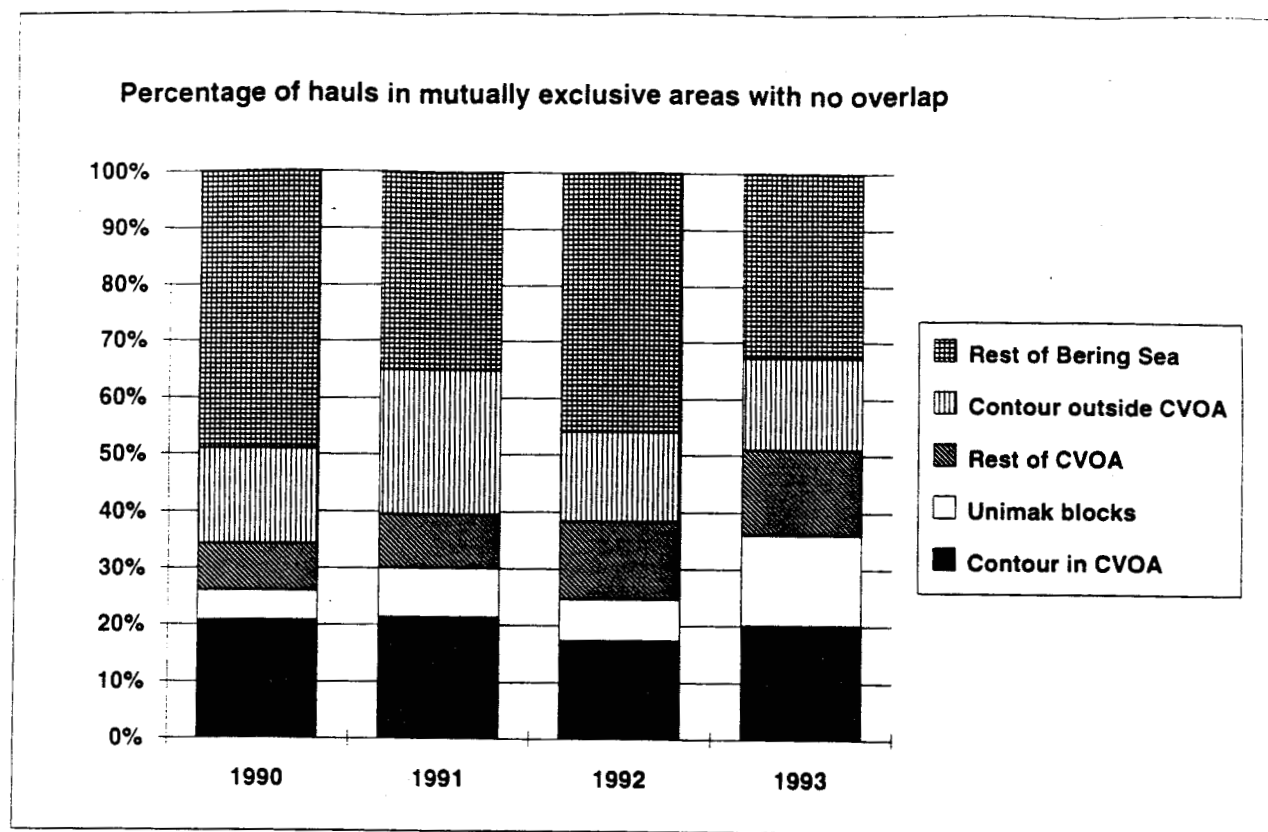
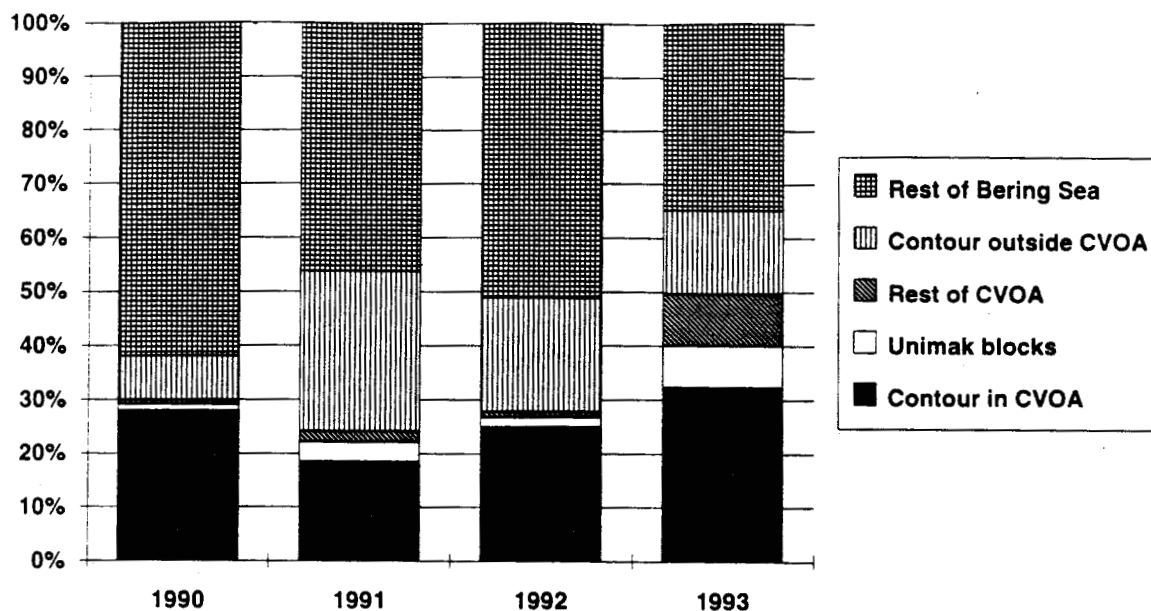


Figure 32. Bering Sea divided into 5 mutually exclusive areas. Top: The percentage of the number of annual hauls from each of 5 non-overlapping areas during July-October. Bottom: The percentage of total annual groundfish catch from each of 5 non-overlapping areas during July-October.

Percentage of hauls - July - October in mutually exclusive areas with no overlap



Percentage of total groundfish catch - July - October. In mutually exclusive areas with no overlap

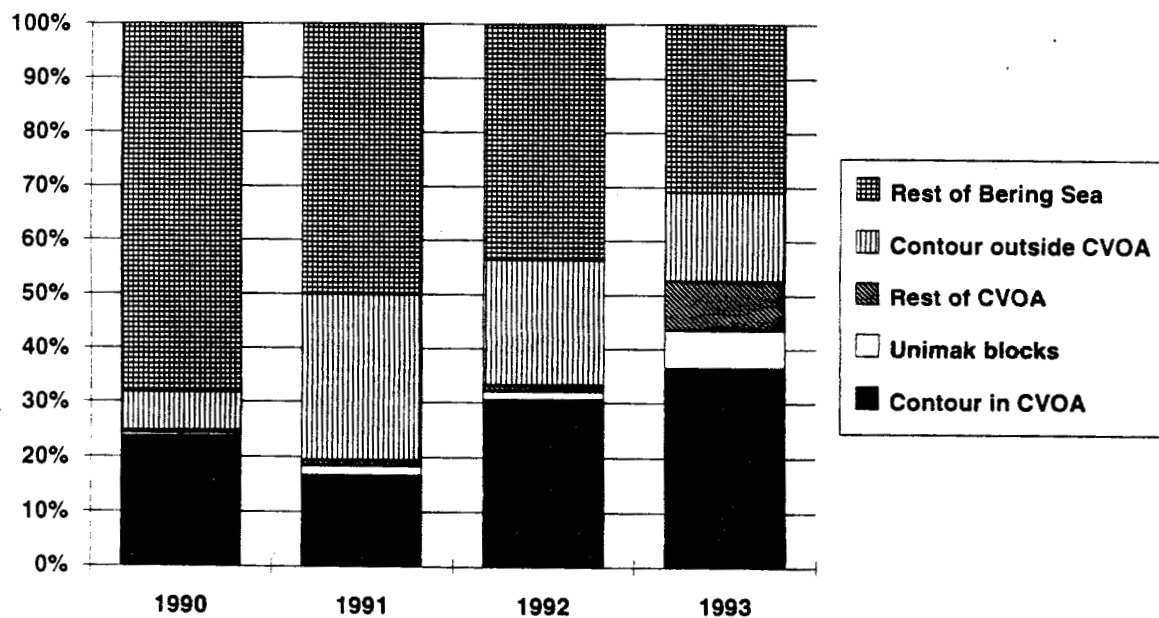
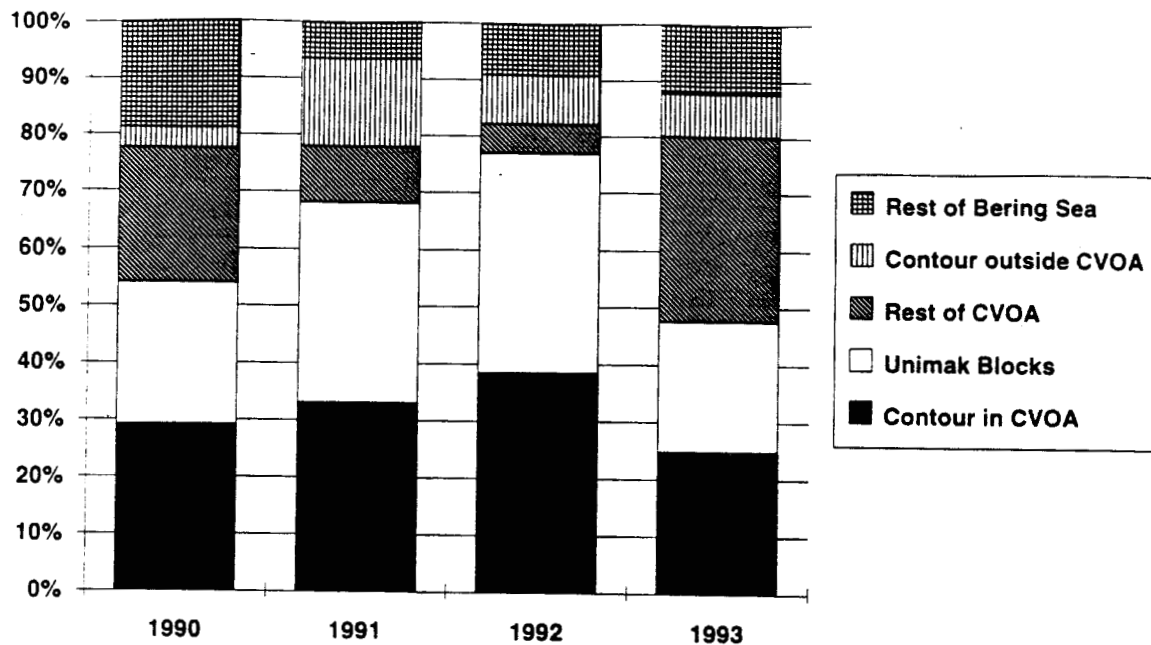


Figure 33. Bering Sea divided into 5 mutually exclusive areas. Top: The percentage of other salmon bycaught in each of 5 non-overlapping areas. Bottom: The percentage of total annual other salmon bycatch taken in each of 5 non-overlapping areas during the months July-October.

Percentage of Other salmon in mutually exclusive areas with no overlap



Percentage of Other salmon by area -July - October. In mutually exclusive areas with no overlap.

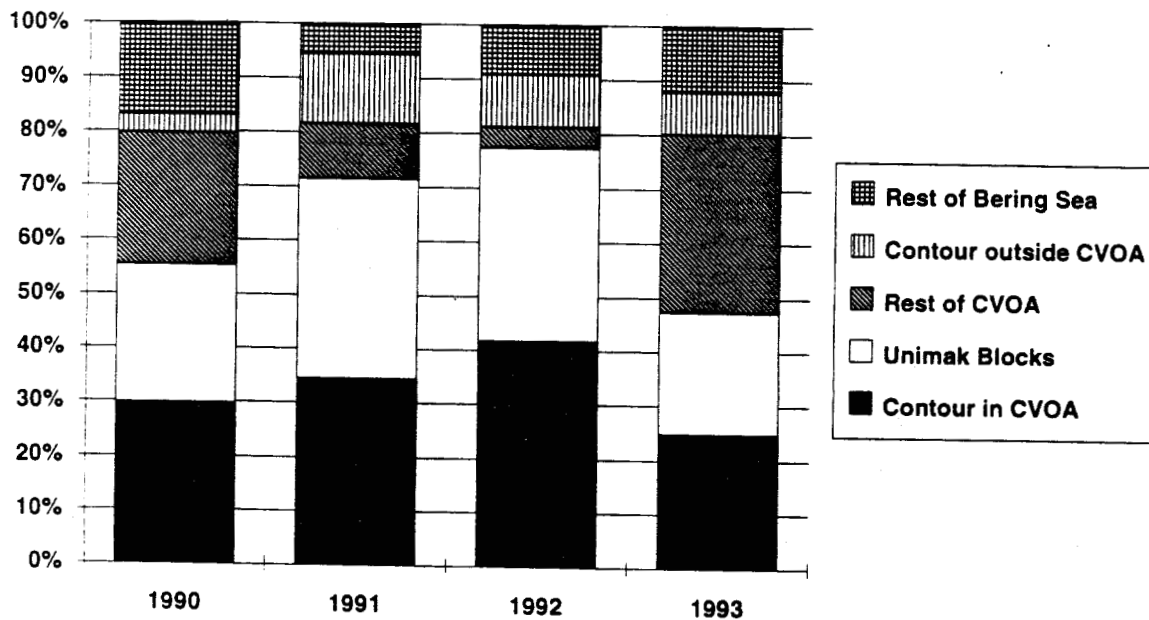


Figure 34.

Reproduced from: McRoy et al. 1985. "The shelf of the Bering Sea showing the approximate locations (X X X X X) of the inner (ca. 50 m isobath), middle (ca. 100 m isobath) and shelf-break (ca. 170 m isobath) fronts which divide the shelf into distinct oceanographic domains".

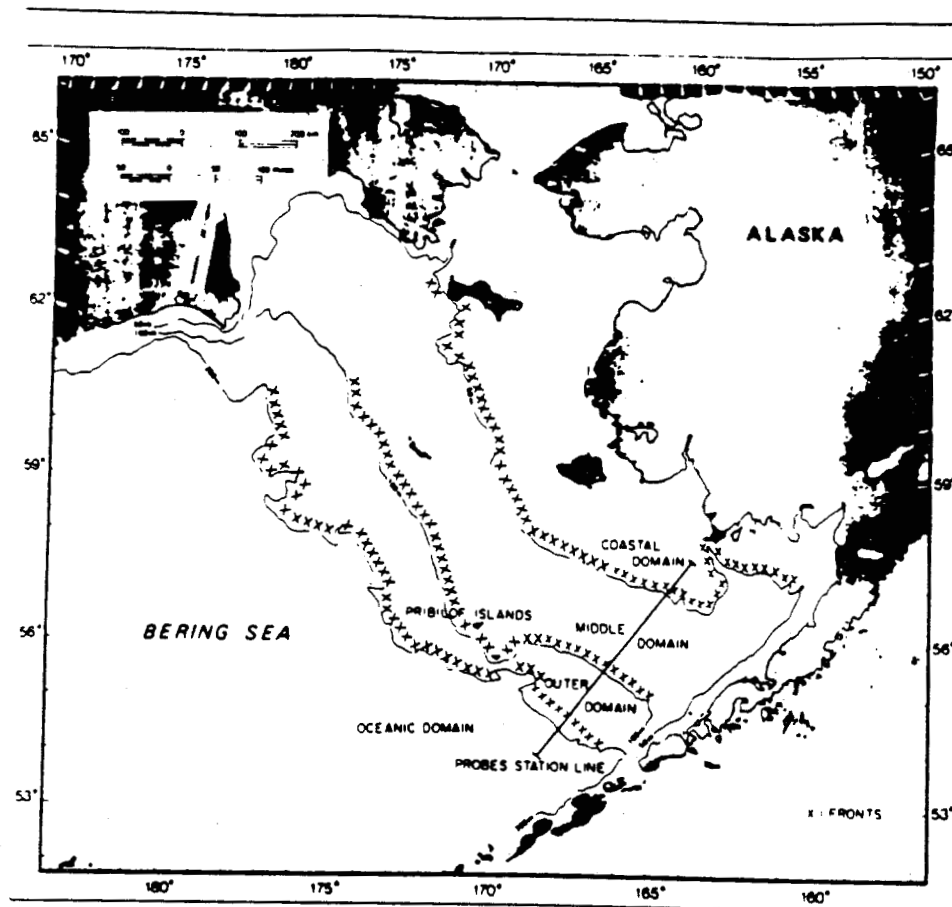


Figure 35.

Reproduced from: McRoy et al. 1985. "The consequences of the Cross-Shelf Model applied to organic matter partitioning and subsequent distributions of zooplankton and seabirds (Modified from Niebauer et al. 1981)".

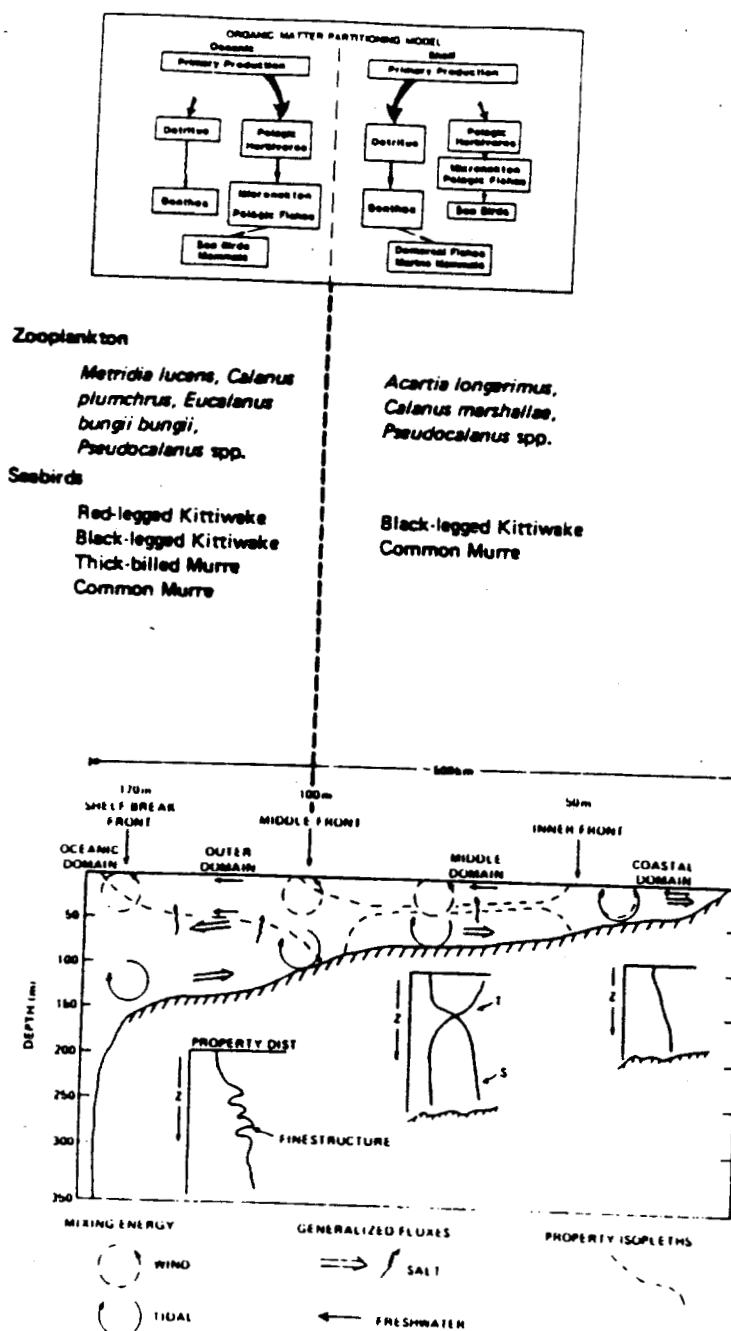


Figure 36. Rate of bycatch by area expressed as the number of other salmon bycaught per metric ton of groundfish catch. For the months of July through October in defined areas in the Bering Sea.

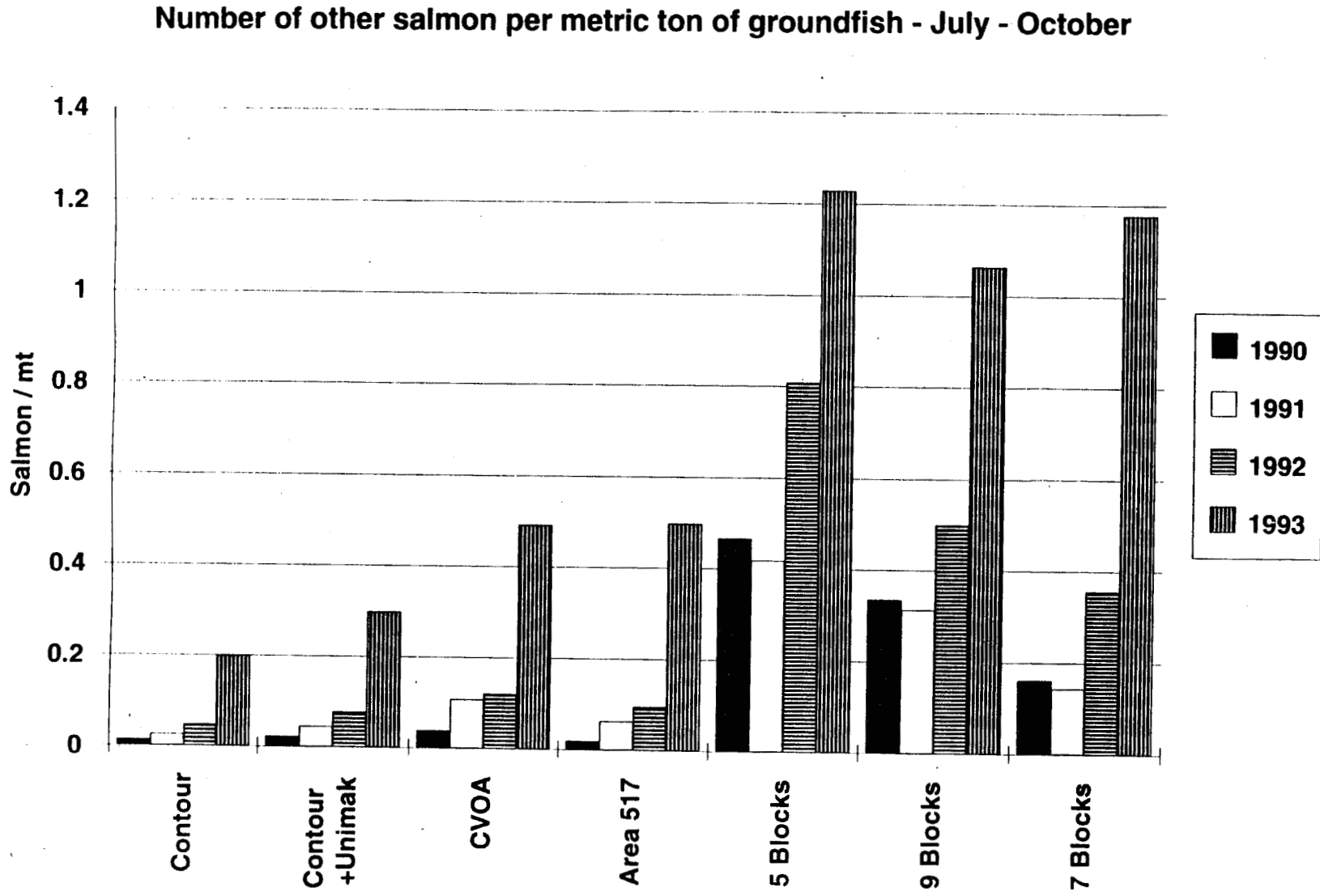


Figure 37.

Cumulative weekly bycatch of other salmon from the Bering Sea trawl fisheries in 1994 as reported on the NMFS Bulletin Board for identified target species.

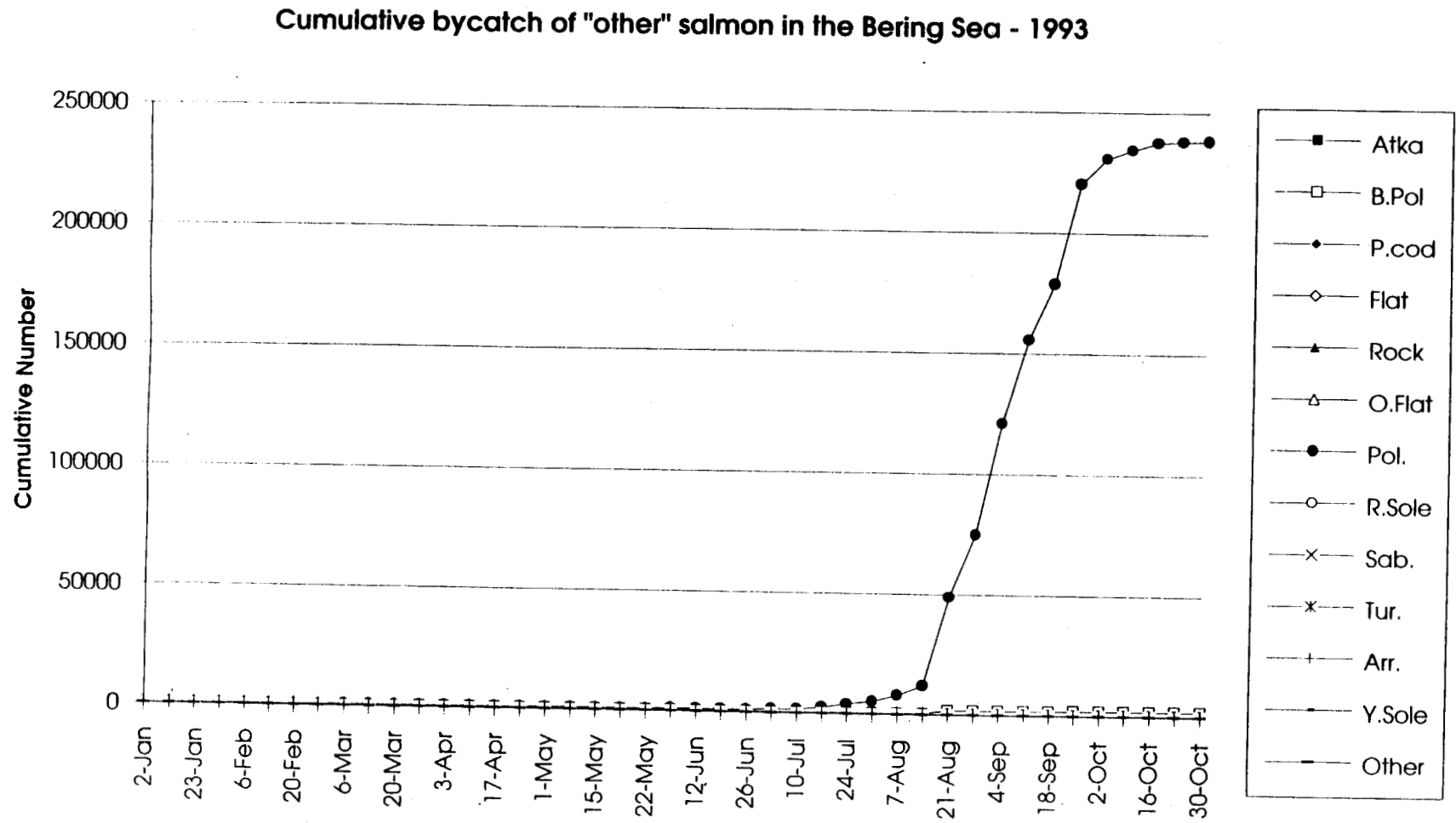


Figure 38. Bycatch of chinook salmon in the trawl fisheries of the Bering Sea as reported by the NMFS observer program. Domestic reporting (since 1989) from the NMFS Bulletin Board.

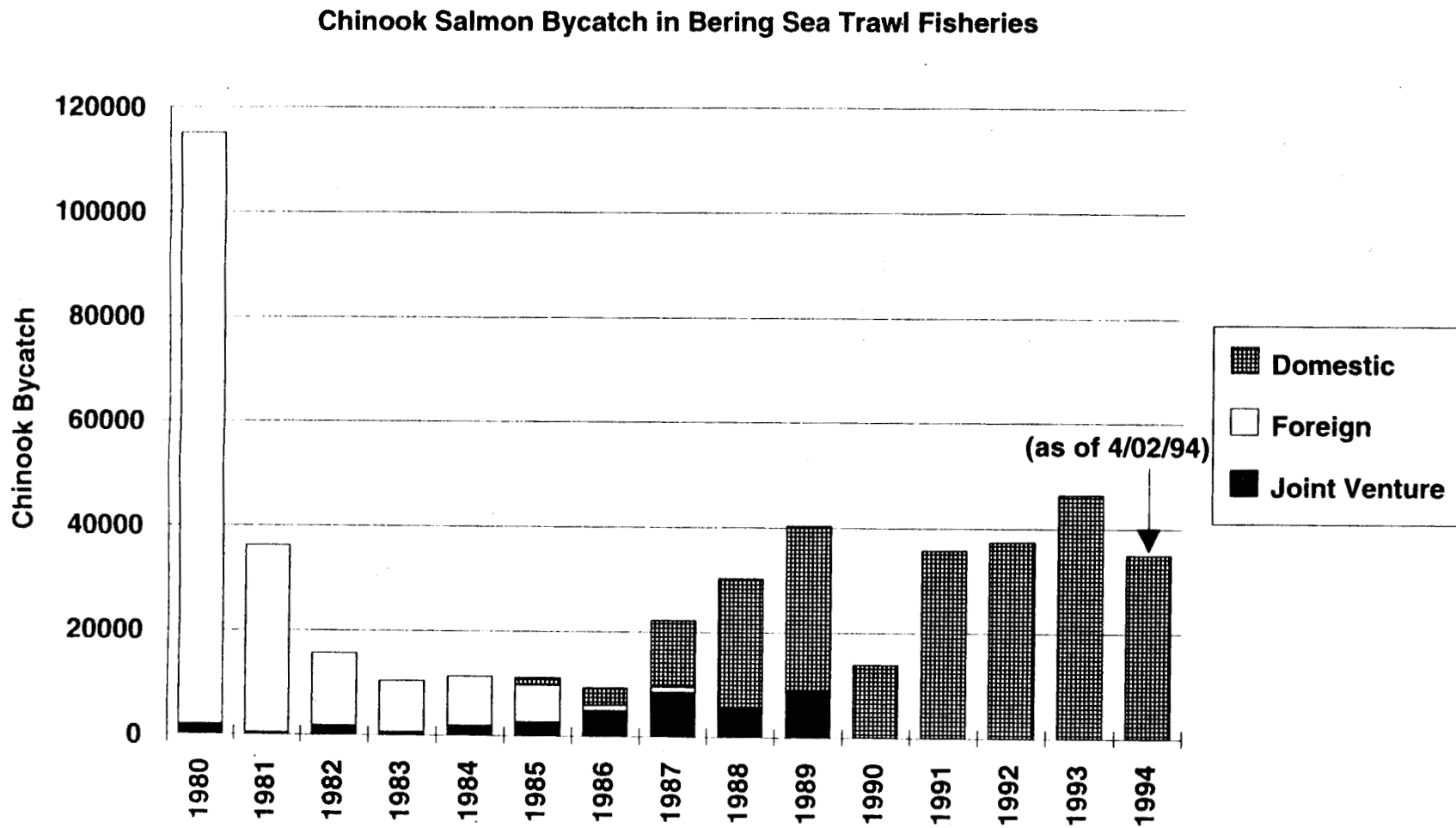


Figure 39. Cumulative weekly chinook salmon bycatch from trawl fisheries in the Bering Sea from 1990 to 4/2/94. (note: data for the final weeks of 1993 not reported \approx 5-6,000 fish).

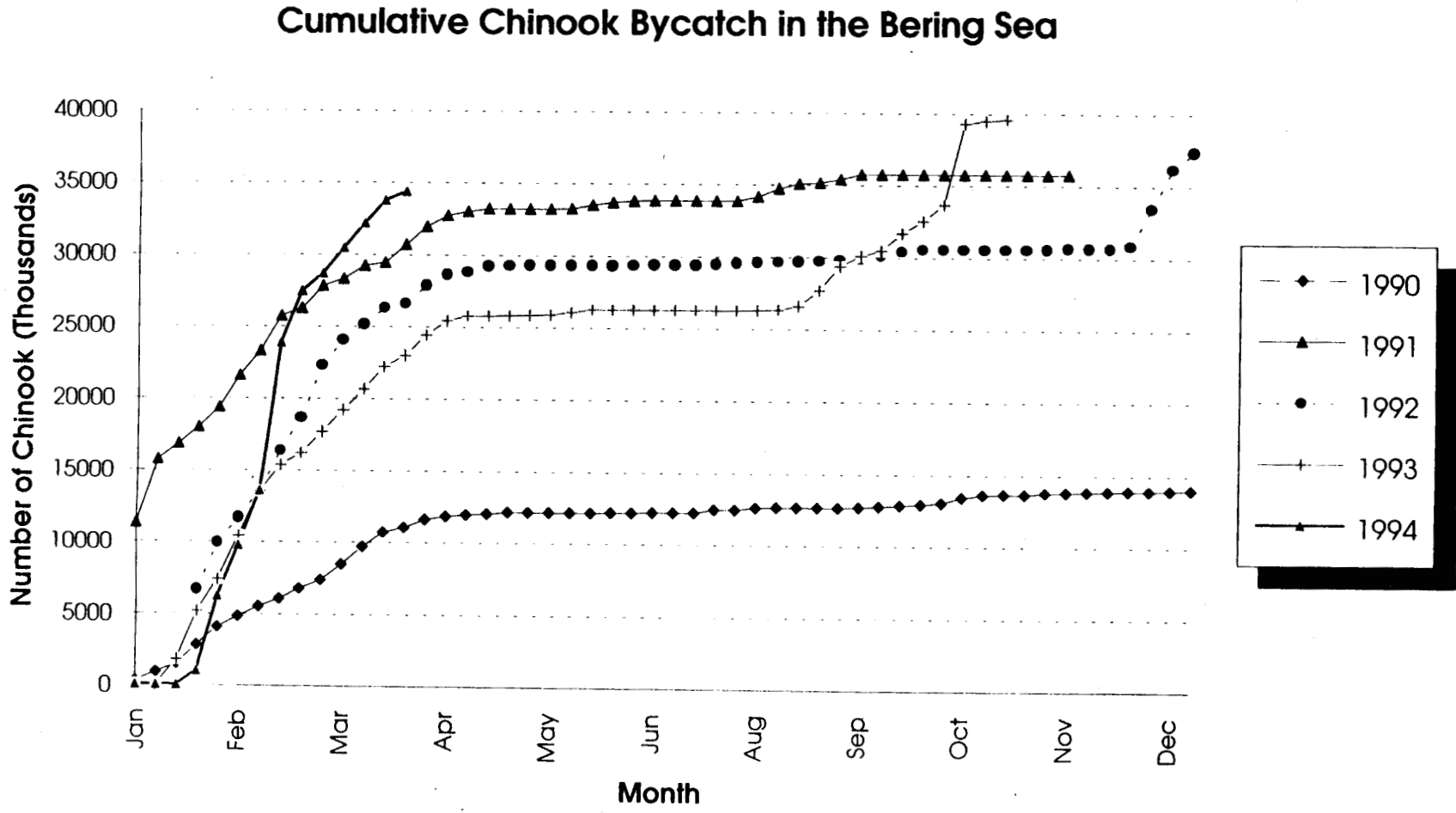


Figure 40. Hauls with a chinook salmon bycatch of more than 20 fish during the years 1990 - 1993 are plotted as dots. 200 m contour, contour buffer, and CVOA borders are indicated. $1/2^\circ$ latitude by 1° longitude blocks with higher salmon bycatch are identified with cross-hatch.

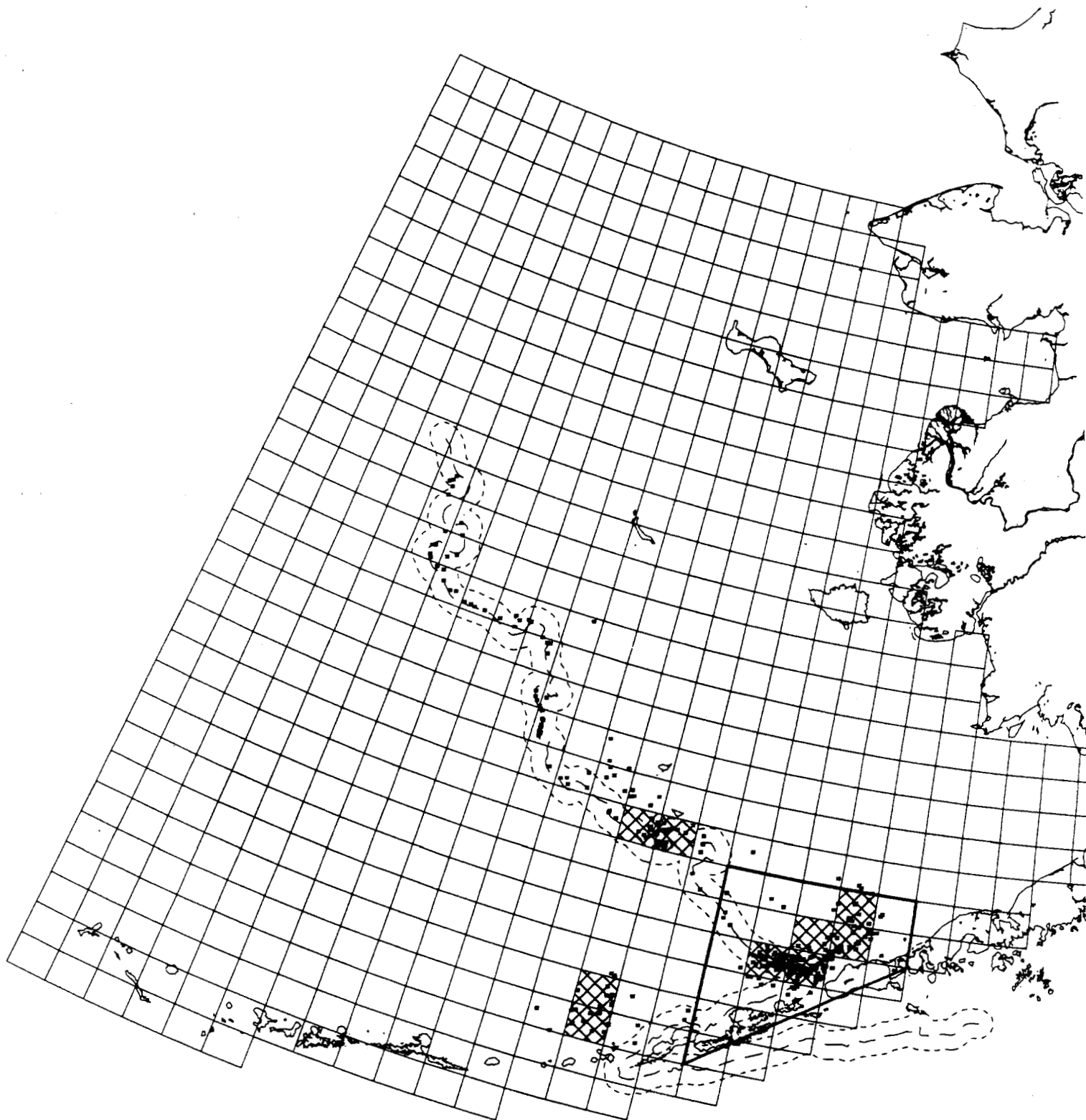


Figure 41. 8 blocks identified with high chinook salmon bycatch as in Figure 40.

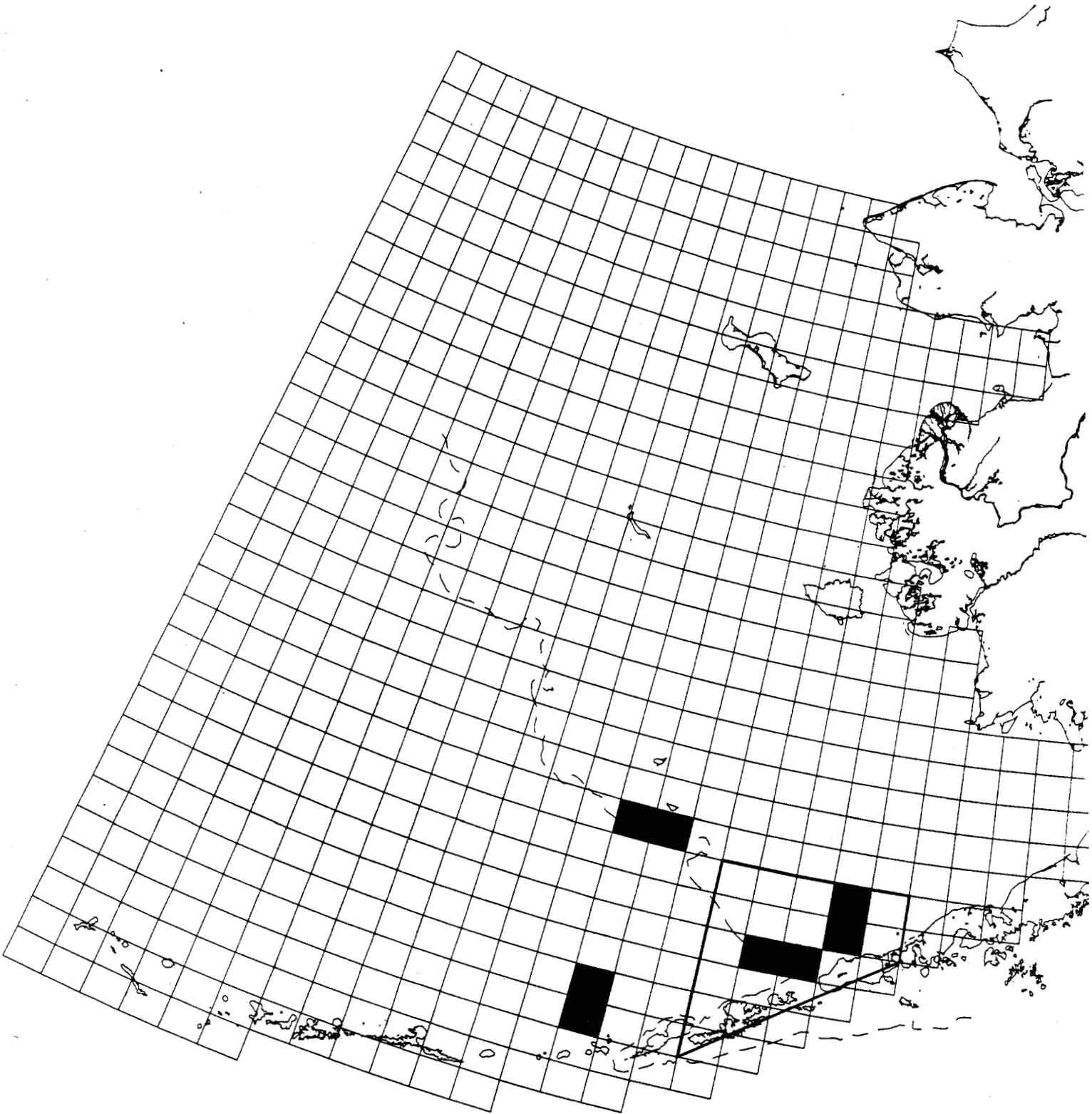


Figure 42. 9 blocks identified with high chinook salmon bycatch as in Figure 40.

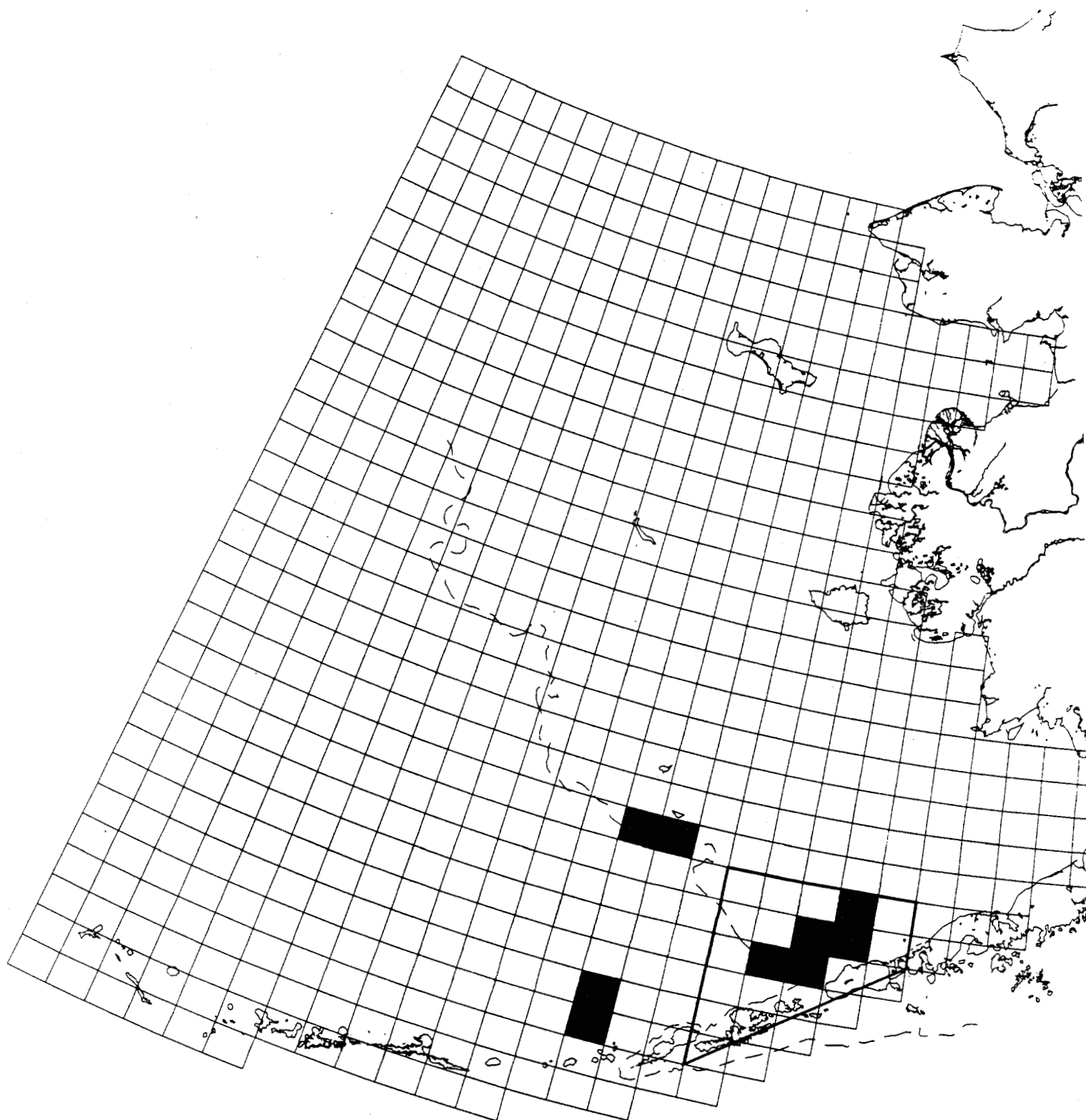


Figure 43. Top: Chinook salmon bycatch from 1990 for the months of January - April and September - December expressed as a percentage of the total for that period. Bottom: Cumulative percent of groundfish catch over the same period. The five identified areas can include portions of other areas (e.g. portions of the contour are contained in the 9 blocks).

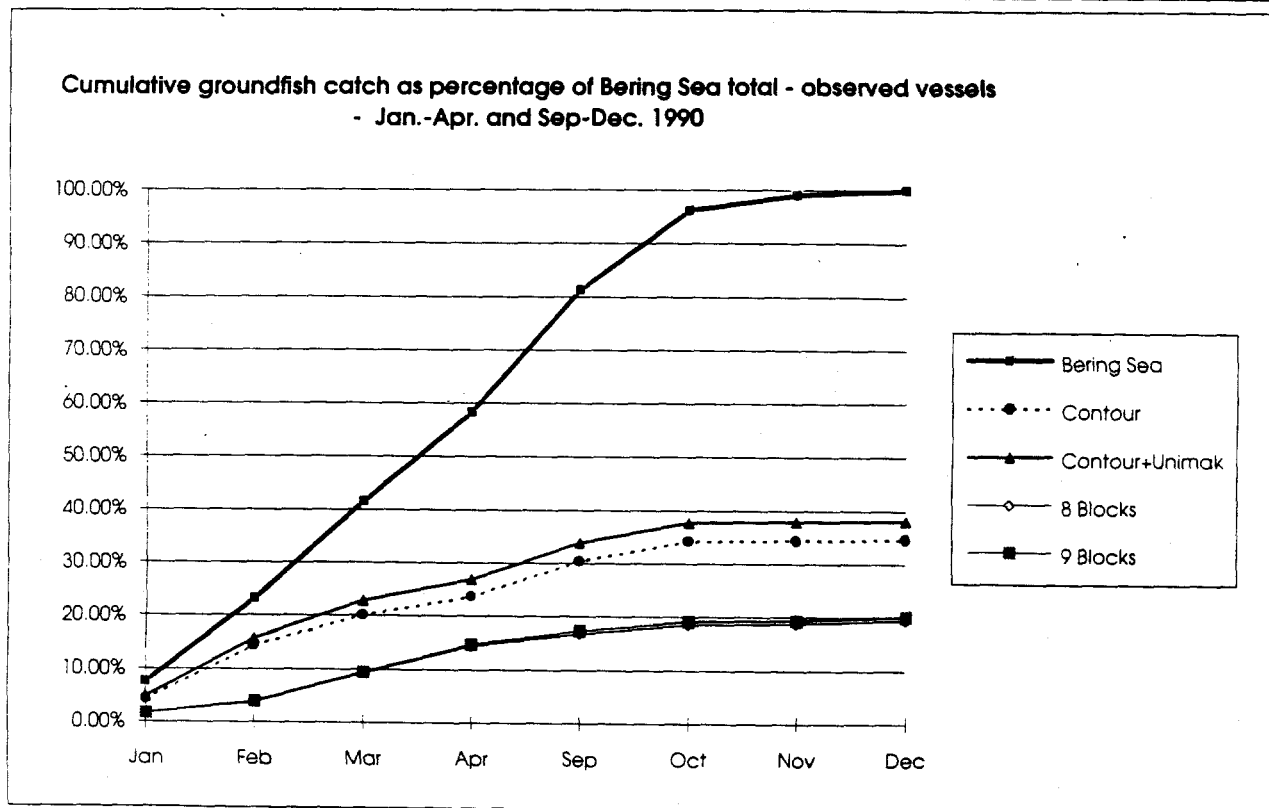
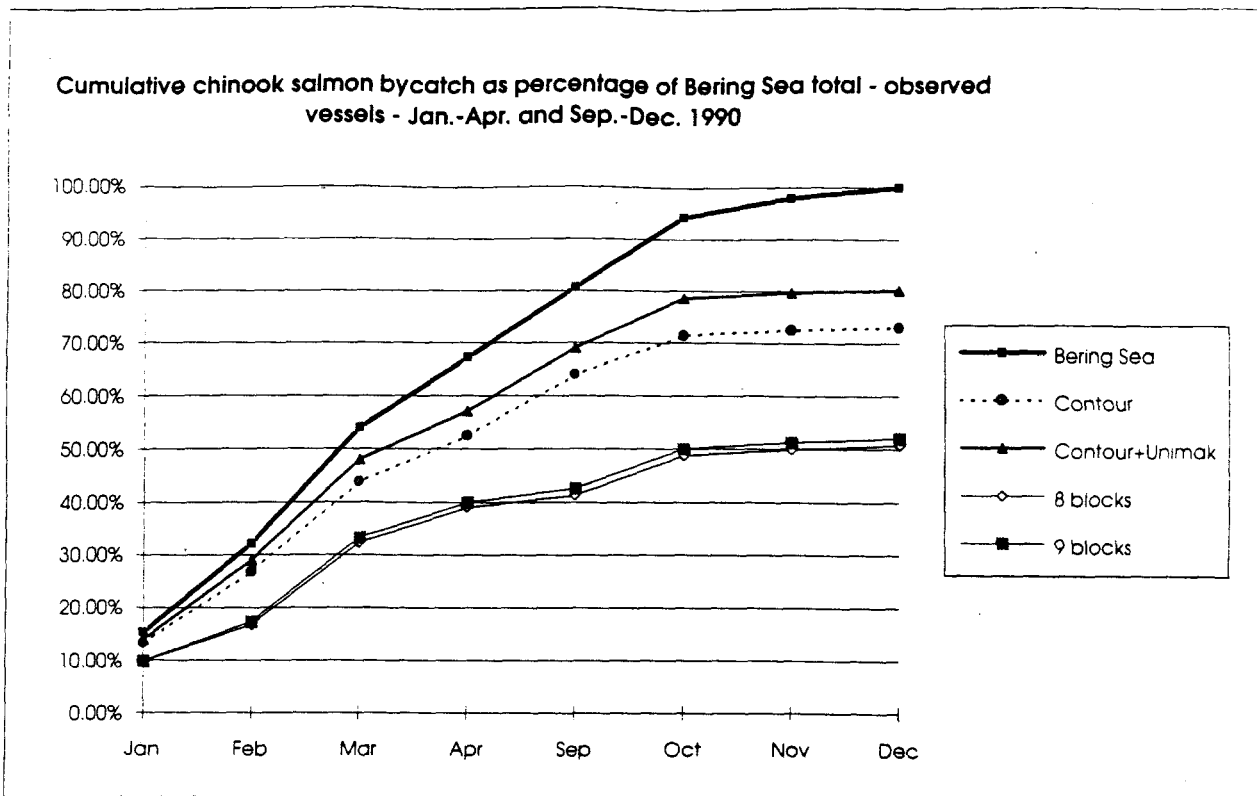


Figure 44.

Top: Chinook salmon bycatch from 1991 for the months of January - April and September - December expressed as a percentage of the total for that period. Bottom: Cumulative percent of groundfish catch over the same period. The five identified areas can include portions of other areas (e.g. portions of the contour are contained in the 9 blocks).

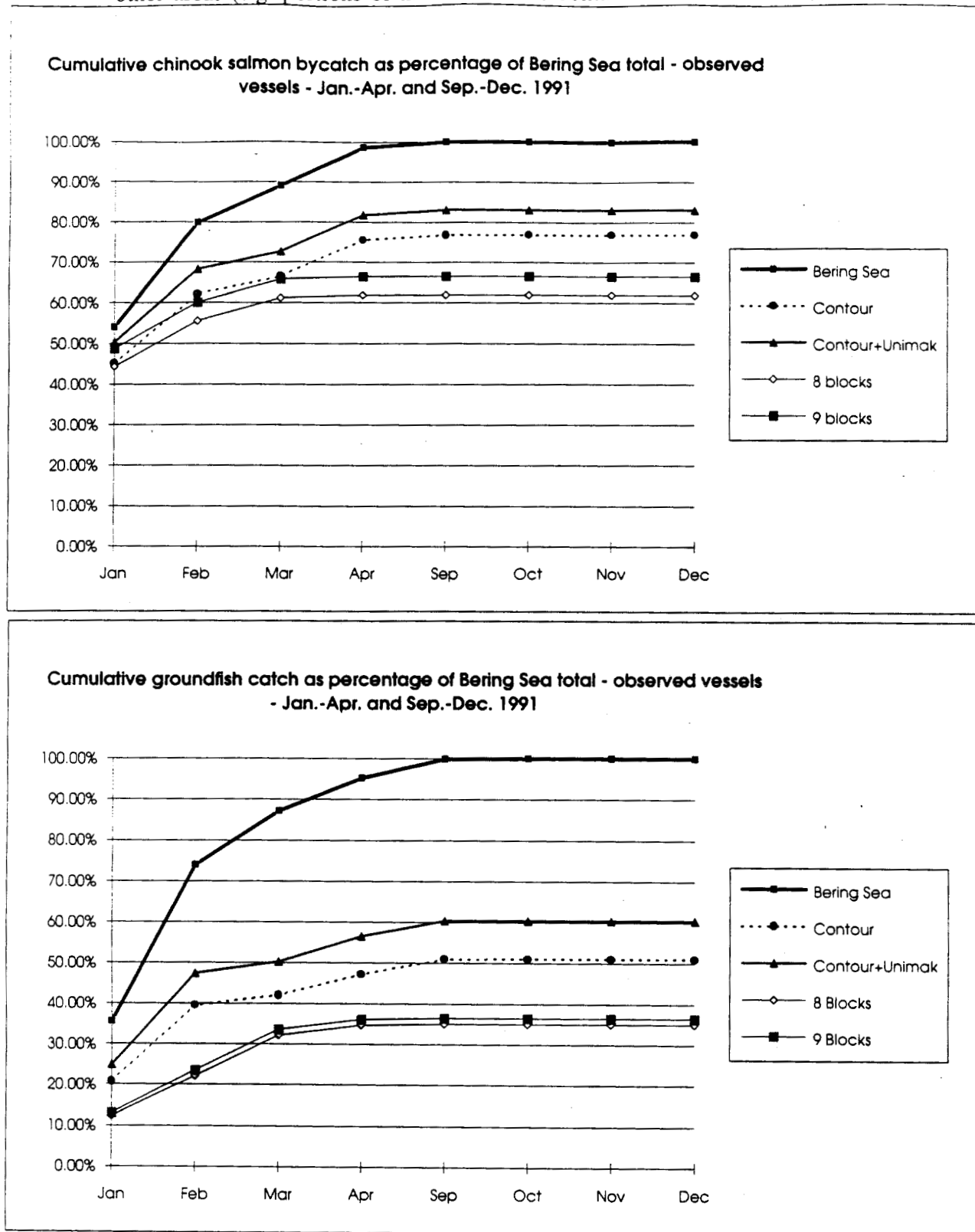


Figure 45. Top: Chinook salmon bycatch from 1992 for the months of January - April and September - December expressed as a percentage of the total for that period. Bottom: Cumulative percent of groundfish catch over the same period. The five identified areas can include portions of other areas (e.g. portions of the contour are contained in the 9 blocks).

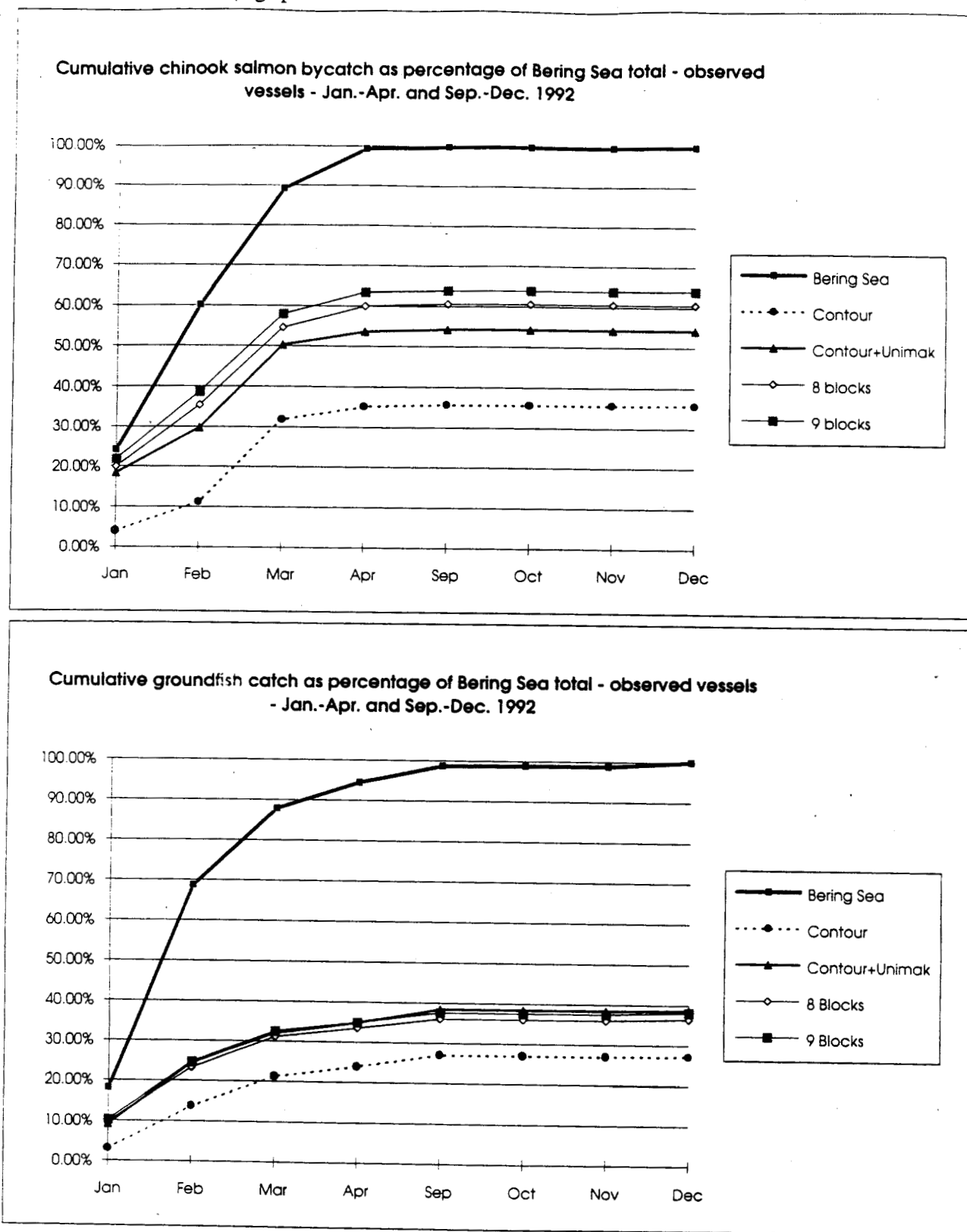


Figure 46. Top: Chinook salmon bycatch from 1993 for the months of January - April and September - December expressed as a percentage of the total for that period. Bottom: Cumulative percent of groundfish catch over the same period. The five identified areas can include portions of other areas (e.g. portions of the contour are contained in the 9 blocks).

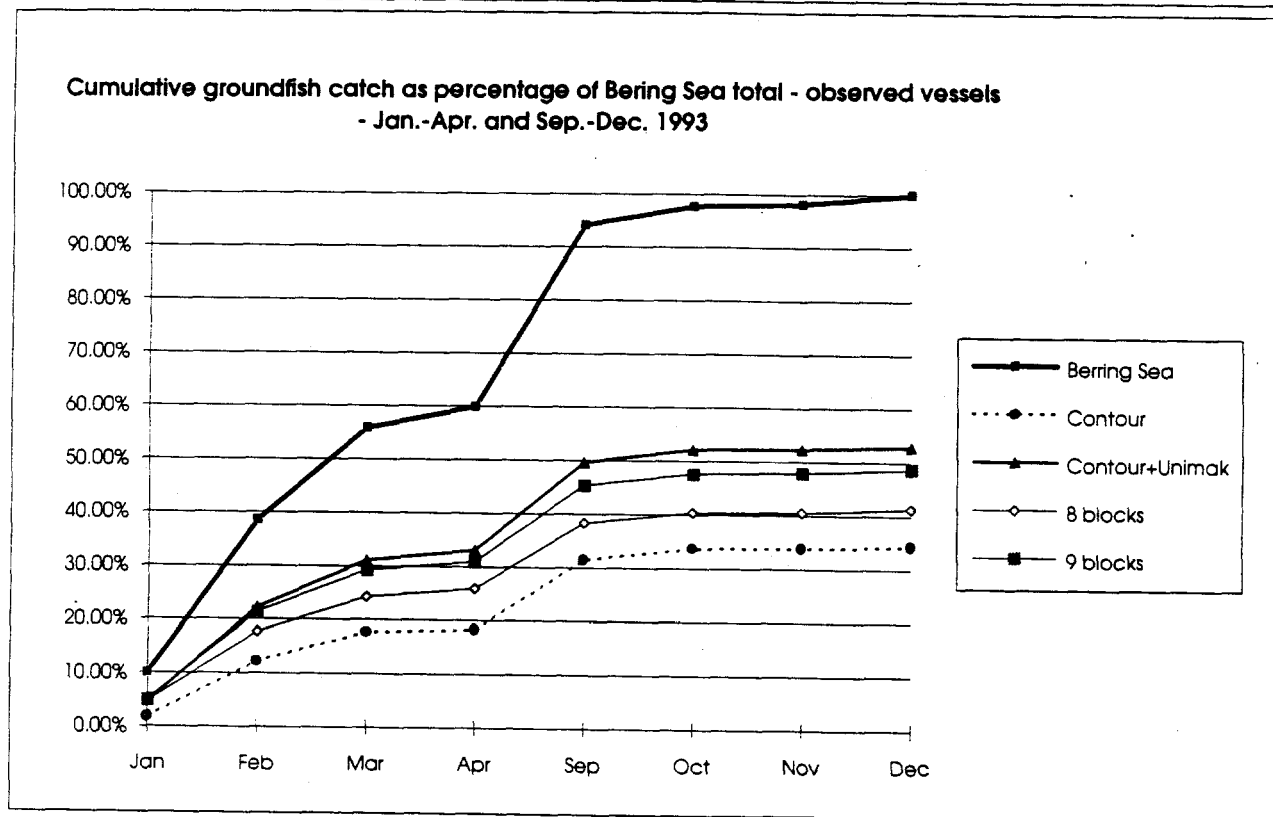
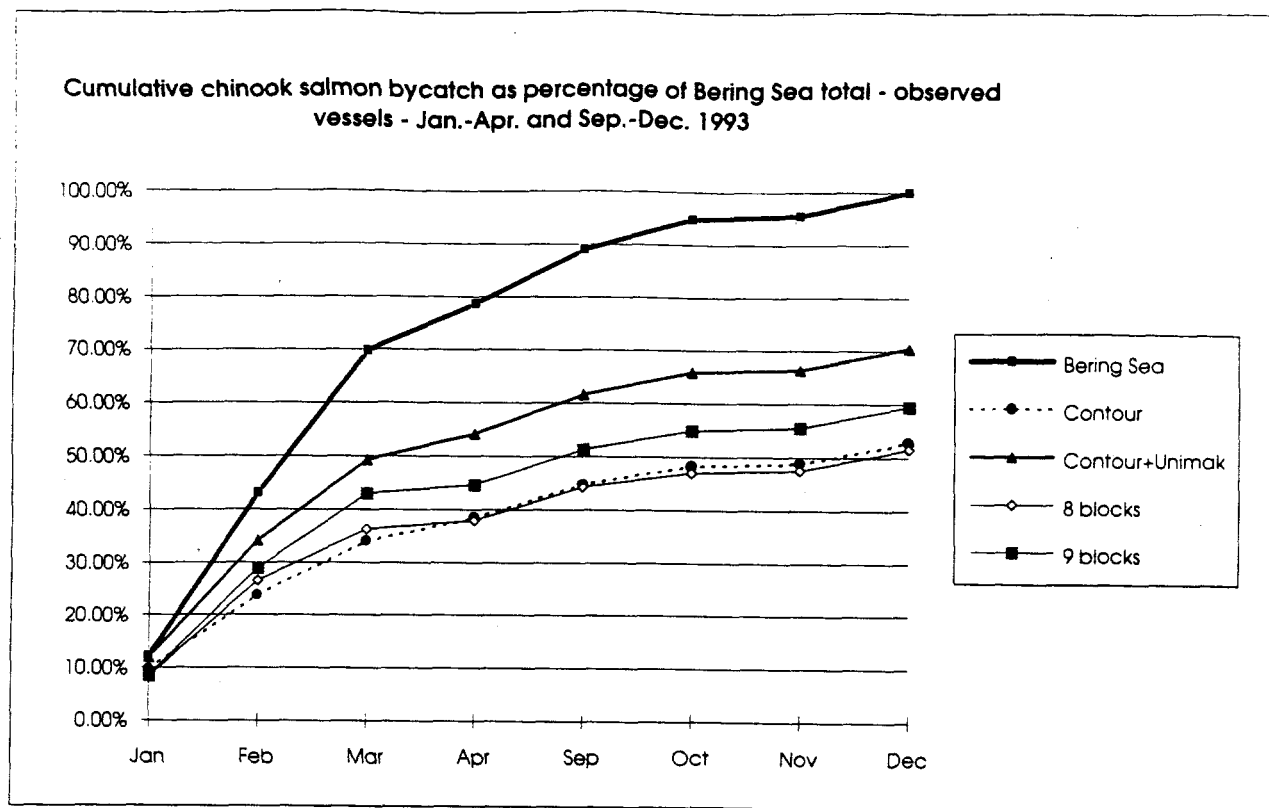


Figure 47. Bering Sea divided into 5 mutually exclusive areas. The percentage of total groundfish catch taken in each of 5 non-overlapping areas during the months January-April and September-December.

Groundfish catch in the Bering Sea - 1990-1993, January - April and September - December. Grouped into mutually exclusive areas with no overlap.

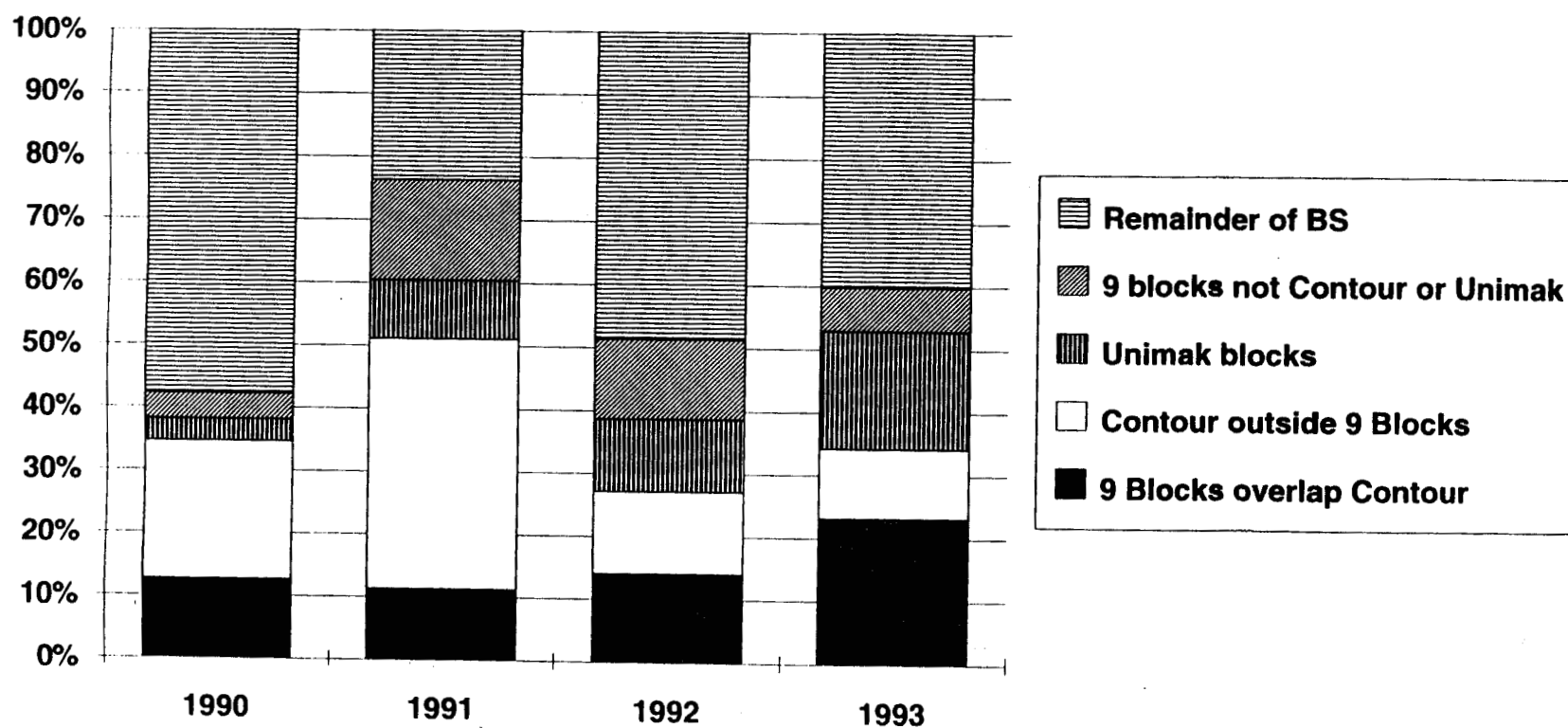
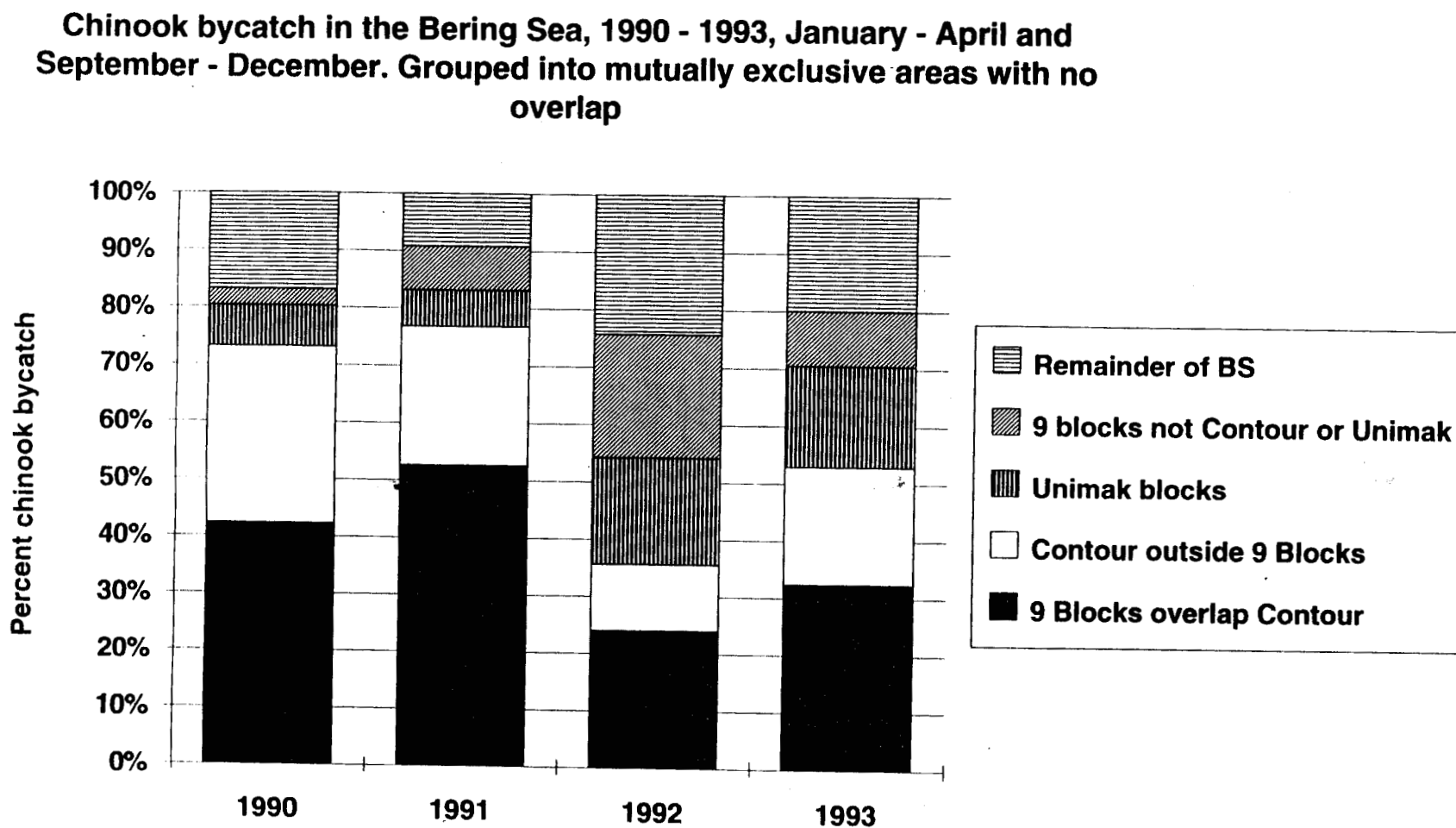


Figure 48. Bering Sea divided into 5 mutually exclusive areas. The percentage of chinook salmon bycatch taken in each of 5 non-overlapping areas during the months January-April and September-December.



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